



**YANMAR®**

***KMH***  
***series***  
**SERVICE MANUAL**  
KMH61V

P/N: 0BKMH-U00400

**MARINE  
GEAR**

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## Section 1

# INTRODUCTION

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This *Service Manual* gives specific instructions for proper repair on the KMH61V marine gear.

Please follow the procedures carefully to ensure quality service.

Yanmar recommends that you read this *Service Manual* completely before starting with repairs, as some of the procedures described are rather complex.

Along with standard tools, Yanmar recommends the use of special tools necessary to perform repairs correctly.

Yanmar products are continuously undergoing improvement. This *Service Manual* has been checked carefully in order to avoid errors. However Yanmar is not liable, for any misrepresentations, errors of description or omissions. Contact an authorized Yanmar marine dealer or distributor for any questions you have regarding this *Service Manual*.

This manual is a living document. Periodic manual revisions are published to document product improvements and changes. This practice ensures the manual has the most current information.

At times the revision involves inserting additional pages in one or more sections. Insert the new information and only the Revision Control Table should be replaced.

This method of revision control represents the most cost-effective solution to providing current, updated information as needed.

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## Section 2

# SAFETY

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Yanmar considers safety of great importance and recommends that anyone that comes into close contact with its products, such as those who install, operate, maintain or service Yanmar products exercise care, common sense and comply with the safety information in this manual and on the engine and marine gear's safety labels. Keep the labels from becoming dirty or torn and replace them if they are lost or damaged. Also, if you need to replace a part that has a label attached to it, make sure you order the new part and label at the same time.



This safety alert symbol appears with most safety statements. It means attention, become alert, your safety is involved! Please read and abide by the message that follows the safety alert symbol.

### **DANGER**

Indicates a hazardous situation which, if not avoided, *will* result in death or serious injury.

### **WARNING**

Indicates a hazardous situation which, if not avoided, *could* result in death or serious injury.

### **CAUTION**

Indicates a hazardous situation which, if not avoided, *could* result in minor or moderate injury.

### **NOTICE**

Indicates a situation which can cause damage to the engine or marine gear, personal property and / or the environment or cause the equipment to operate improperly.

## SAFETY PRECAUTIONS

### General Information

There is no substitute for common sense and careful practices. Improper practices or carelessness can cause burns, cuts, mutilation, asphyxiation, other bodily injury or death. This information contains general safety precautions and guidelines that must be followed to reduce risk to personal safety. Special safety precautions are listed in specific procedures. Read and understand all of the safety precautions before operation or performing repairs or maintenance.

### Before You Service the Marine Gear

#### CAUTION

The safety messages that follow have CAUTION level hazards.



NEVER permit anyone to install or operate the engine without proper training.

- Read and understand this Operation Manual before you operate or service the marine gear to ensure that you follow safe operating practices and maintenance procedures.
- Safety signs and labels are additional reminders for safe operating and maintenance techniques.
- See your authorized Yanmar marine dealer or distributor for additional training.

### During Servicing

#### DANGER

The safety messages that follow have DANGER level hazards.

#### Crush Hazard

NEVER stand under a hoisted marine gear. If the hoist mechanism fails, the marine gear will fall on you.

#### Fire Hazard



Ensure that appropriate fire detection and extinguishing equipment are installed and checked periodically for proper operation. Check with local authorities.

**⚠ WARNING**

The safety messages that follow have **WARNING** level hazards.

**Explosion Hazard**

While the engine is running or the battery is charging, hydrogen gas is being produced and can be easily ignited. Keep the area around the battery well-ventilated and keep sparks, open flame and any other form of ignition out of the area.

Diesel fuel is flammable and explosive under certain conditions.

Never use a shop rag to catch the fuel.

Wipe up all spills immediately.

**Fire Hazard**

Undersized wiring systems can cause an electrical fire.

**Sever Hazard**

NEVER wear jewelry, unbuttoned cuffs, ties or loose-fitting clothing and ALWAYS tie long hair back when working near moving / rotating parts such as the flywheel or PTO shaft. Keep hands, feet and tools away from all moving parts.

NEVER service the marine gear while under tow or if the engine is running at idle speed. The propeller may rotate under these circumstances.

**Alcohol and Drug Hazard**

NEVER operate or service the engine or marine gear while under the influence of alcohol or drugs or feeling ill.

**Exposure Hazard**

ALWAYS wear personal protective equipment including appropriate clothing, gloves, work shoes, eye and hearing protection as required by the task at hand.

**Entanglement Hazard**

NEVER leave the key in the key switch when you are servicing the engine or marine gear. Someone may accidentally start the engine and not realize you are servicing it.

If the vessel has more than one engine, NEVER service a marine gear if either of the engines are running. In multi-engine configurations the propeller for an engine that is shut down may rotate if any of the other engines are running.

**Burn Hazard**

Some of the engine and marine gear surfaces become very hot during operation and shortly after shut-down. Keep hands and other body parts away from hot engine surfaces.

**Sudden Movement Hazard**

ALWAYS stop the engine before beginning service.

**⚠ WARNING****Exhaust Hazard**

NEVER block windows, vents, or other means of ventilation if the engine is operating in an enclosed area. All internal combustion engines create carbon monoxide gas during operation and special precautions are required to avoid carbon monoxide poisoning.

**⚠ CAUTION**

The safety messages that follow have CAUTION level hazards.

**Poor Lighting Hazard**

Ensure that the work area is adequately illuminated. ALWAYS install wire cages on portable safety lamps.

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**Tool Hazard**

ALWAYS use tools appropriate for the task at hand and use the correct size tool for loosening or tightening marine gear parts.

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**Flying Object Hazard**

ALWAYS wear eye protection when servicing the marine gear or when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.

**NOTICE****The safety messages that follow have NOTICE level hazards.**

It is important to perform daily checks as listed in the *Operation Manual*.

Periodic maintenance prevents unexpected downtime, reduces the number of accidents due to poor engine performance and helps extend the life of the engine and marine gear.



**ALWAYS** be environmentally responsible.

Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.

NEVER dispose of hazardous materials by dumping them into a sewer, on the ground or into ground water or waterways.

Before operating the engine, check marine gear oil level.

Observe the following environmental operating conditions to maintain marine gear performance and avoid premature marine gear wear:

- NEVER run the marine gear if the ambient temperature is above +45°C (+113°F) or below -15°C (+5°F).
- If the ambient temperature exceeds +45°C (+113°F) the marine gear may overheat and cause the marine gear oil to break down.
- If the ambient temperature falls below -15°C (+5°F) rubber components such as gaskets and seals will harden causing premature marine gear wear and damage.
- Contact your authorized Yanmar marine dealer or distributor if the marine gear will be operated in either temperature extreme.

NEVER attempt to modify the marine gear's design or safety features.

If you have more than one engine, you cannot shift the marine gear into the "B" position after you install the "emergency nut."

Observe the following environmental operating conditions to maintain marine gear performance and avoid premature marine gear wear:

- Avoid operating in extremely dusty conditions.
- Avoid operating in the presence of chemical gases or fumes.

Protect the electrical components from damage when you use steam or use high-pressure water to clean the engine or marine gear.

Establish a periodic maintenance plan according to the engine and marine gear application and make sure you perform the required periodic maintenance at intervals indicated. Failure to follow these guidelines will impair the marine gear's safety and performance characteristics, shorten the marine gear's life and may affect the warranty coverage on your marine gear.

***NOTICE***

If the marine gear oil temperature is too high, stop engine immediately and check the marine gear oil level and check the oil cooler for proper coolant and water flow.

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**New Marine Gear Break-In:**

On the initial engine start-up, allow the engine to idle for approximately 15 minutes while you check for proper marine gear function and marine gear oil leaks.

During the break in period, carefully observe marine gear indicators (if any) for proper marine gear function.

During the break in period, check the marine gear oil levels frequently.



### *Section 3*

# **GENERAL SERVICE INFORMATION**

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## SAFETY PRECAUTIONS

### NOTICE

Only use the marine gear oil specified. Other marine gear oils may affect the warranty coverage, cause the internal marine gear components to seize and / or shorten the marine gear life.

NEVER mix different types of marine gear oil. This may adversely affect the lubricating properties of the marine gear oil.

ALWAYS keep the oil level between the upper and the lower lines on the marine gear dipstick.

NEVER overfill the marine gear with oil. Overfilling may result in internal damage.

Prevent dirt and debris from contaminating the marine gear oil. Carefully clean the oil plug, the dipstick and the surrounding area before you remove either one.

The correct level of the marine gear oil is very important for proper marine gear function:

- Check the marine gear for the proper amount of marine gear oil before you start the engine for the first time.
- Running the engine with insufficient oil level in the marine gear will cause damage to the internal marine gear components.

If the marine gear oil temperature is too high, stop the engine immediately and check the marine gear oil level and check the oil cooler for proper coolant and water flow.

Never lift the marine gear and the engine by the marine gear limiting eye. Use the engine lifting eye to lift the engine and the marine gear as an assembly.

## GENERAL INFORMATION

This marine gear has a built-in wet type multi-disk clutch and is operated by the oil pressure of the hydraulic pump.

The major components are:

- Damper
- Idle shaft assembly
- Input shaft assembly
- Support shaft assembly
- Output shaft assembly
- Hydraulic pump
- Housing

The lube oil for each of the parts is distributed by the hydraulic pump in a forced lubrication system.

When the mechanical shift lever or the electric shift valve is actuated, oil pressure is applied to move the clutch to the FORWARD or the REVERSE position.

The clutch for clockwise rotation of the output shaft is fitted to the input shaft, and the clutch for counterclockwise rotation of the output shaft is fitted to the support shaft.

The marine gear oil (lube oil) is cooled by a multi-pipe marine gear oil cooler.

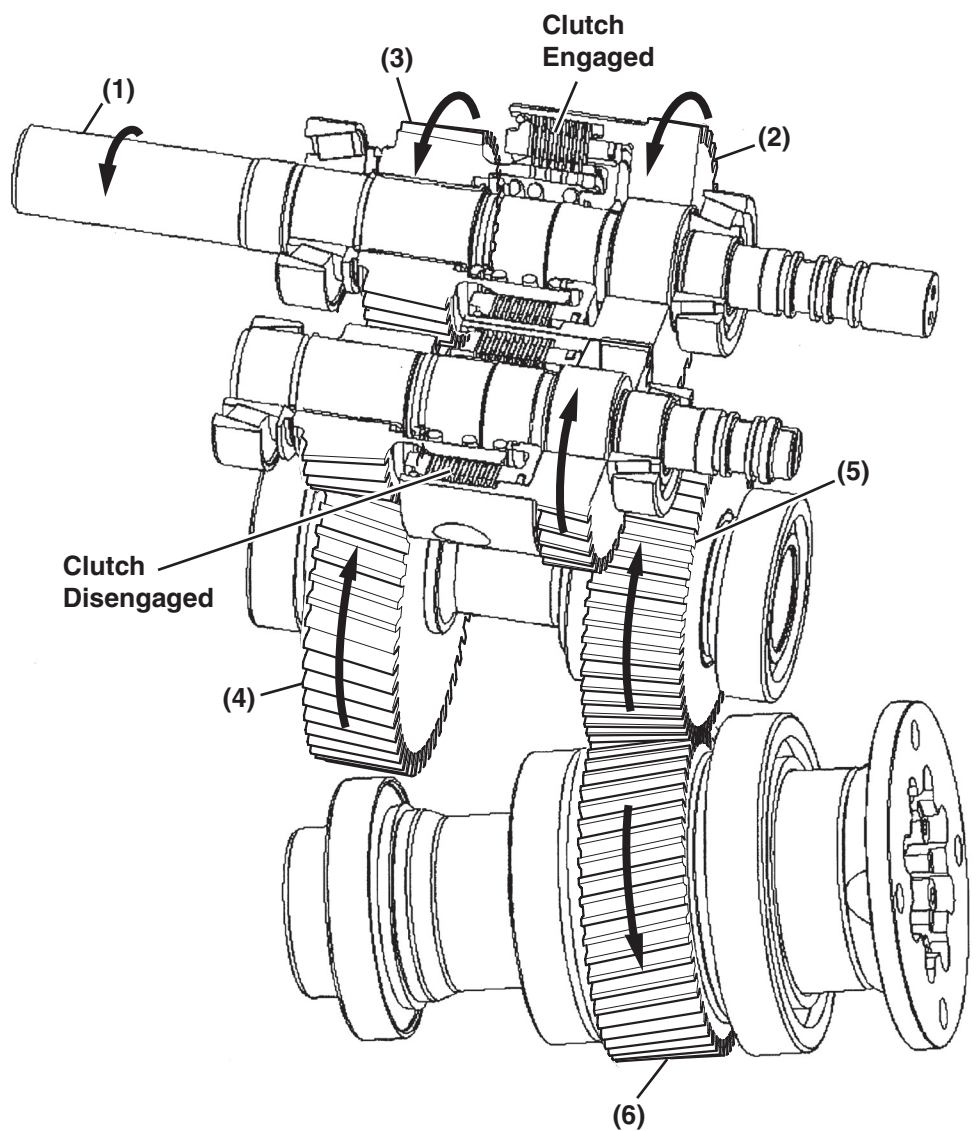
## MARINE GEAR SYSTEM

### Drive Flow in Shift Lever Position “A”

Input shaft clutch engaged - Support shaft clutch disengaged.

The output shaft rotation is the same as the input shaft (engine) rotation.

Drive Flow = Input Shaft (1)→Input Shaft Clutch Housing Gear (2)→Input Shaft Pinion Gear (3)→Idle Drive Gear (4)→Idle Driven Gear (5)→Output Shaft Gear (Output Shaft) (6)



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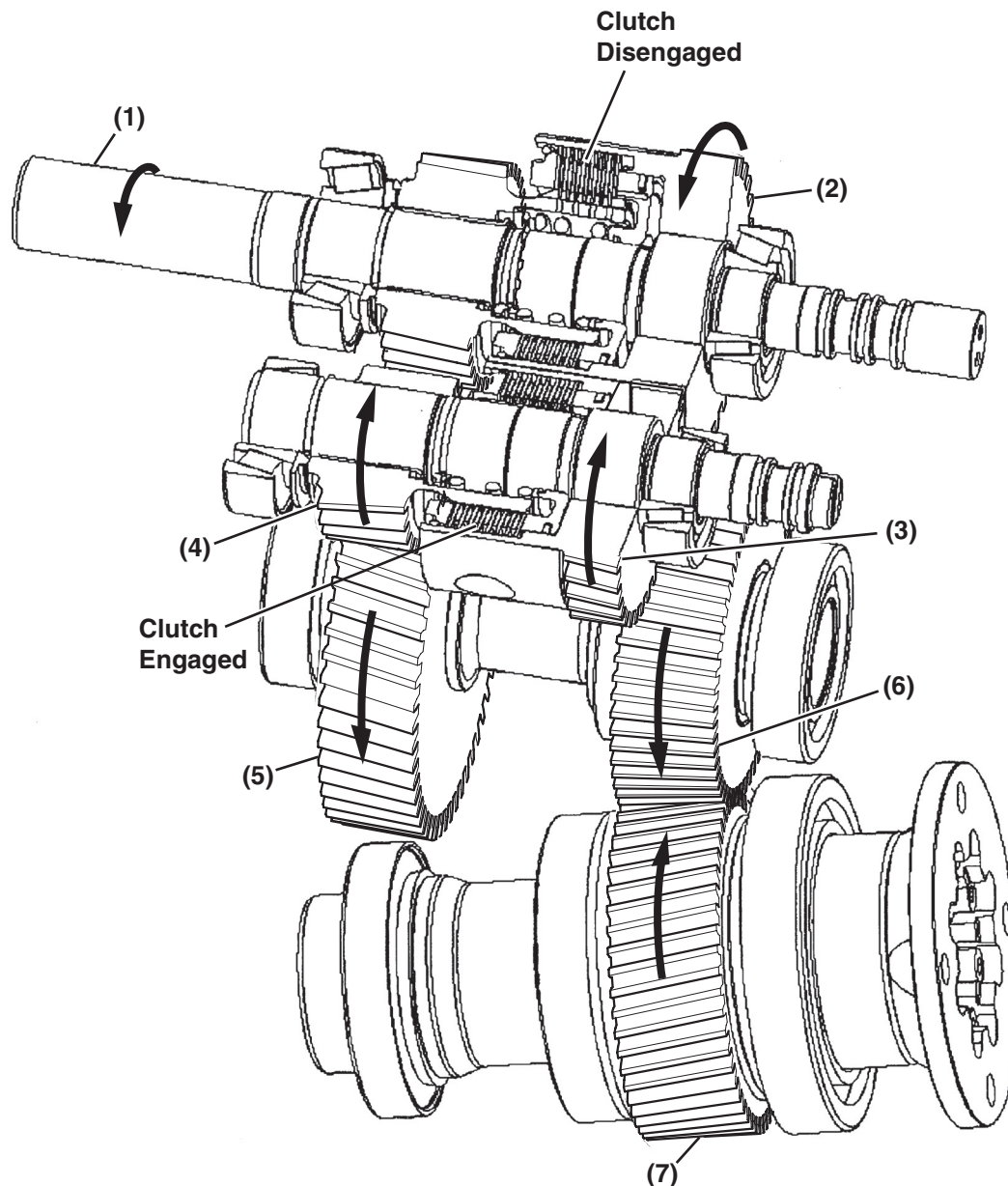
**Figure 3-1**

**Drive Flow in Shift Lever Position “B”**

Support shaft clutch engaged - Input shaft clutch disengaged

The output shaft rotation is the opposite of the input shaft (engine) rotation.

Drive Flow = Input Shaft (1)→Input Shaft Clutch Housing Gear (2)→Support Shaft Clutch Housing Gear (3)→Support Shaft Pinion Gear (4)→Idle Drive Gear (5)→Idle Driven Gear (6)→Output Shaft Gear (Output Shaft) (7)



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**Figure 3-2**

## SHIFTING THE MARINE GEAR

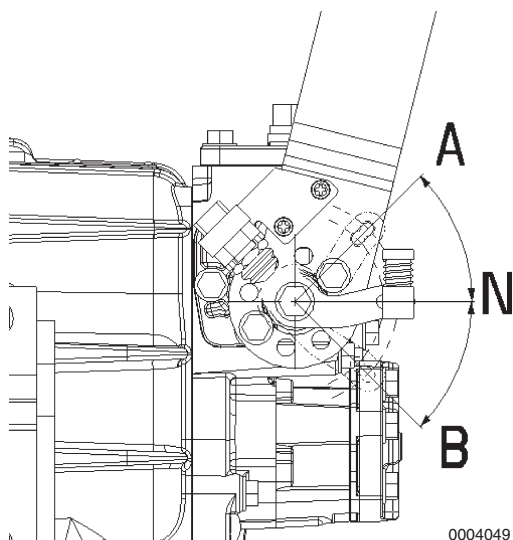
The marine gear is shifted by moving the shifting lever. *NOTICE: During normal operation, the marine gear should only be shifted with the engine at idle speed.*

### Shifting Positions:

A = The propeller rotation is the same as the engine rotation.

N = NEUTRAL position

B = The propeller rotation is the opposite of the engine rotation.



**Figure 3-3**

The operating oil temperature of the marine gear is 50 to 80°C (122 to 176°F).

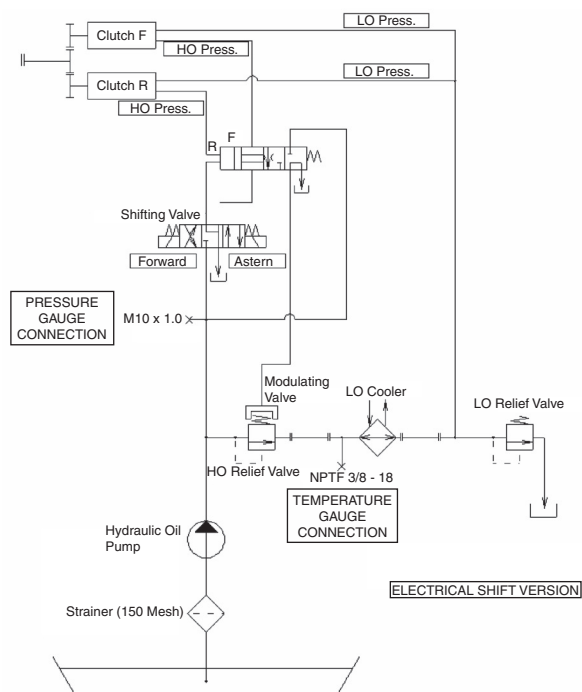
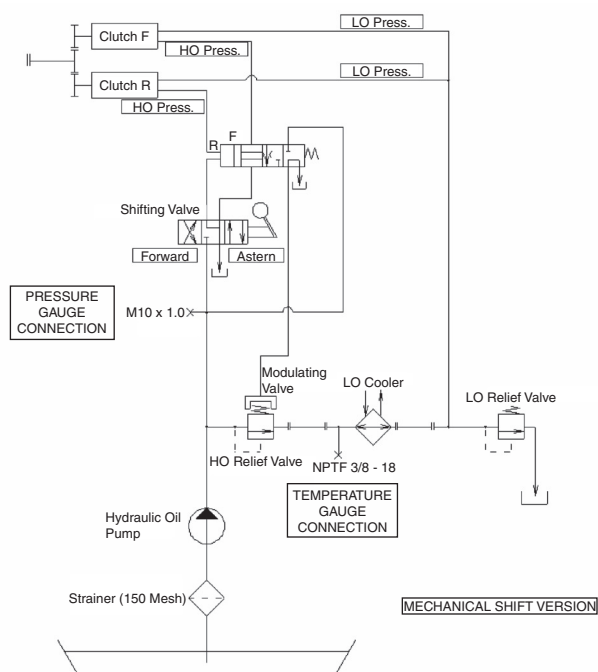
A connection port for a temperature sensor has been provided. See *Marine Gear Major Component Locations* on page 3-8 for the location.

## MARINE GEAR SPECIFICATIONS

Items		KMH61V	Remarks
Type		V-Drive Hydraulic	—
Angle		12°	—
Maximum Input Torque		1070 N·m (789 lbf-ft)	—
Input Speed		700 - 3300 min <sup>-1</sup> (rpm)	—
Reduction Ratio (F / R)		2.43 / 2.43	—
		1.98 / 1.98	—
		1.49 / 1.49	—
		1.24 / 1.24	—
Direction of Rotation	Input Shaft	Clockwise	Viewed from stern
	Output Shaft	Clockwise (Recommended) or Counterclockwise	
Shift		Mechanical Cable or Electrical (Optional)	—
Shifting Pressure*		4.33 - 4.43 MPa (628 - 643 psi)	—
Lubrication		Forced Lubrication	—
Oil Type		API (American Petroleum Institute) Service Grade Class: CF or higher	Never use multi-grade oil or mix the oil types. Single-grade oil must be used.
		Viscosity: SAE 30	
		Recommended Oil: Yanmar Marine Super Oil SAE 30	
Oil Quantity (Effective)		7.5 L (0.4 L) 7.9 qt (0.484 qt)	—
Dimensions	L	360.7 mm (14.2 in.)	SAE #3
	H	251.4 mm (9.9 in.)	—
	W	380.0 mm (15.0 in.)	—
Bellhousing Size / Clutch Size		SAE #3 / SAE 11.5 in.	—
Dry Mass	Marine Gear	83.9 kg (185.0 lb)	Without the damper, the mounting feet, and the marine gear oil cooler.
	Marine Gear Oil Cooler	6.6 kg (14.6 lb)	With the bracket, the hoses and the fittings.
	Damper	7.5 kg (16.5 lb)	—

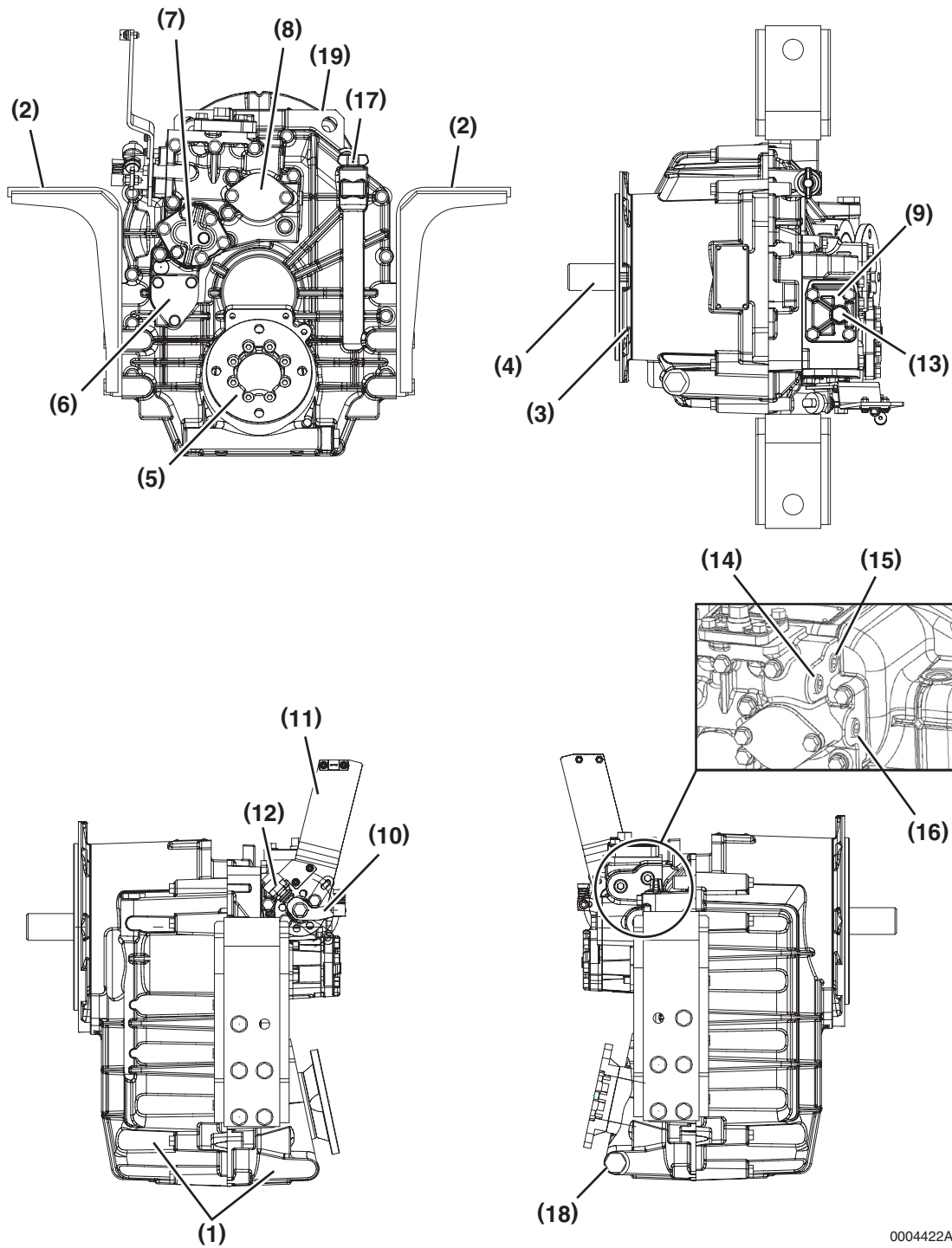
\* Changes in the oil temperature or input speed will affect the shifting pressure.

## HYDRAULIC DIAGRAM



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Figure 3-4

**MARINE GEAR MAJOR COMPONENT LOCATIONS**

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**Figure 3-5**

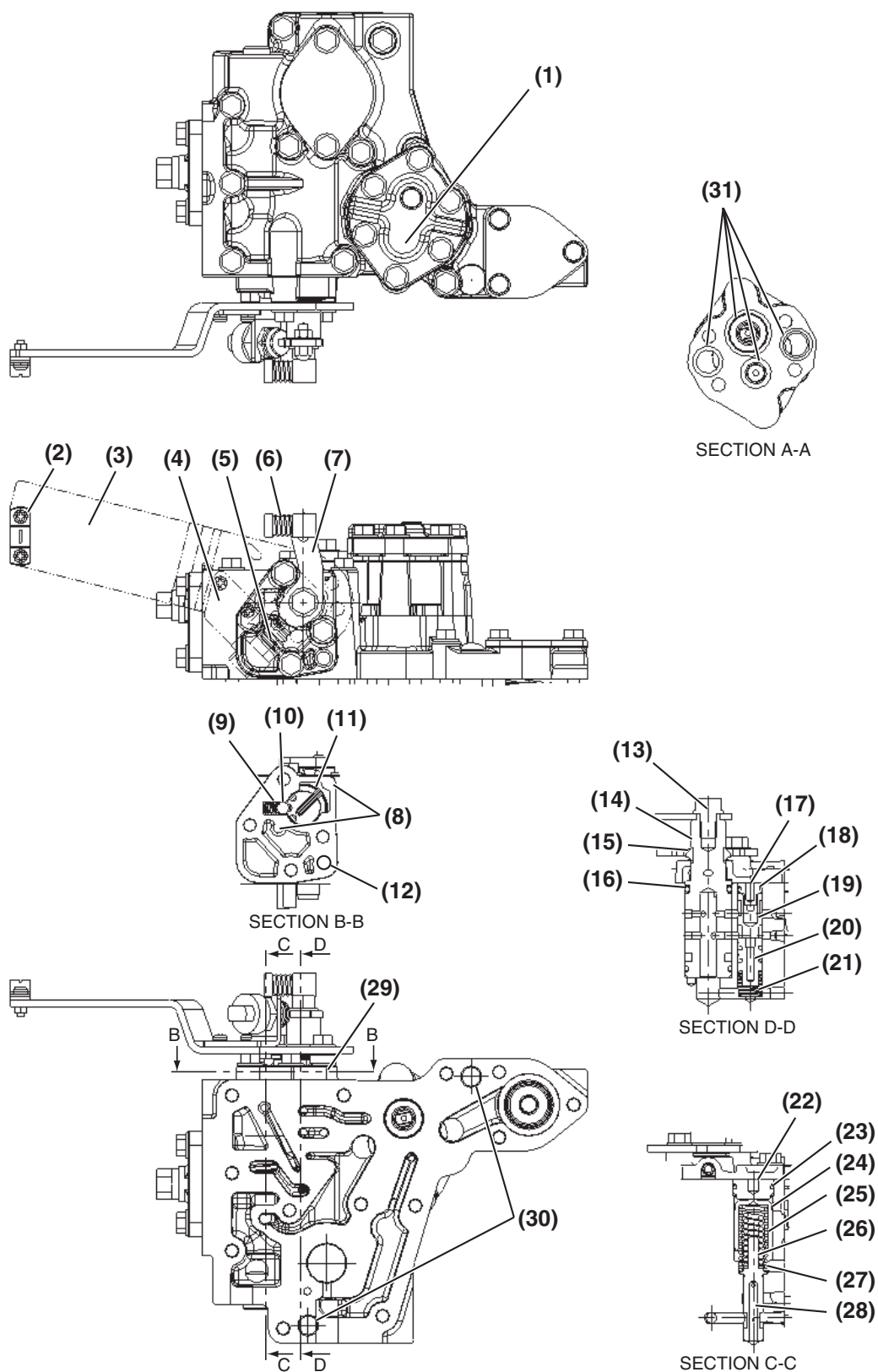


- 1 – Main Case (Halves)
- 2 – Mounting Feet
- 3 – Mounting Flange
- 4 – Input Shaft
- 5 – Output Shaft Flange
- 6 – Oil Strainer Cover
- 7 – Oil Pump
- 8 – PTO Cover
- 9 – Cover for Optional Trolling Valve
- 10 – Mechanical Shift Lever

- 11 – Shift Cable Bracket
- 12 – Neutral Safety Switch
- 13 – Hydraulic Oil Pressure Test Port
- 14 – Lubricating Oil Pressure Test Port  
(Temperature Sensor Port)
- 15 – Oil Cooler Supply Port (Oil to Cooler)
- 16 – Oil Cooler Return Port (Oil from Cooler)
- 17 – Oil Dipstick and Oil Fill Port
- 18 – Oil Drain Plug with Magnet and Seal
- 19 – Marine Gear Lifting Eye

*NOTICE: NEVER use the marine gear lifting eye to lift the engine and the marine gear as an assembly. Use the engine lifting eyes to lift the engine and the marine gear. Only use the marine gear lifting eye to lift the marine gear as a separate component.*

## CASE PLATE COMPONENT LOCATION



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Figure 3-6

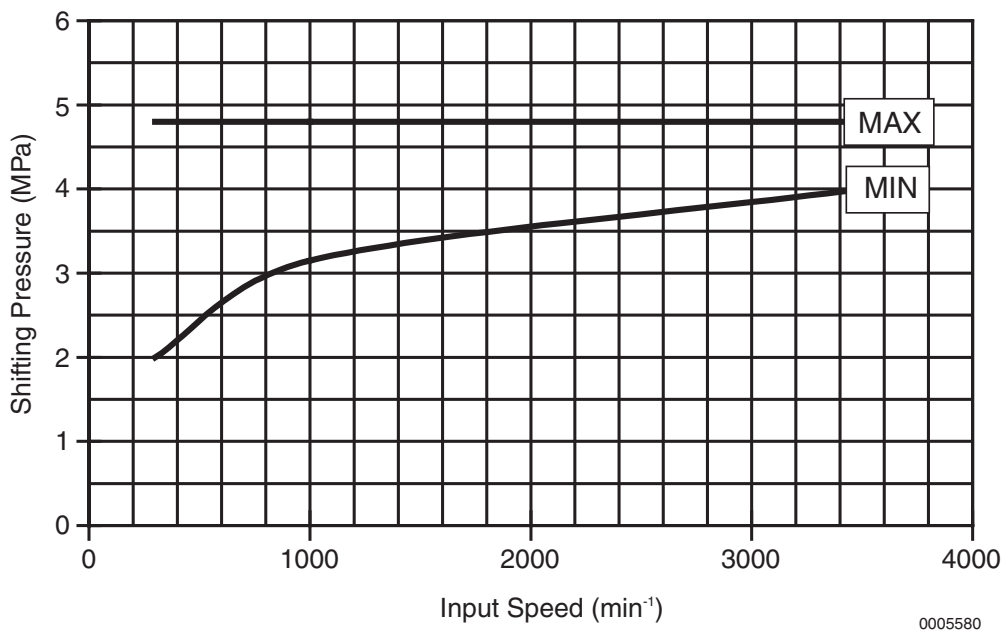
- 1 – Oil Pump
- 2 – Clamp
- 3 – Shift Cable Bracket
- 4 – Switch Support
- 5 – Neutral Safety Switch
- 6 – Ball Joint
- 7 – Shifting Lever
- 8 – Parallel Pin
- 9 – Spring
- 10 – Ball
- 11 – Spring Pin
- 12 – O-Ring
- 13 – Bolt
- 14 – Shifting Valve
- 15 – V-Ring
- 16 – O-Ring

- 17 – Valve Cover
- 18 – O-Ring
- 19 – Pilot Valve
- 20 – Throttle Valve
- 21 – Spring
- 22 – Cover
- 23 – O-Ring
- 24 – Modulating Valve
- 25 – Spring “B”
- 26 – Spring “A”
- 27 – Shim
- 28 – Hydraulic Oil Relief Valve
- 29 – Shift Valve Cover
- 30 – Parallel Pins
- 31 – O-Rings

## SHIFTING PRESSURE

The shifting pressure is the hydraulic pressure. The shifting pressure must be between the minimum and the maximum line in the below performance graph at all times. If not, *See Troubleshooting on page 5-1.*

See the *Marine Gear Major Component Locations* on page 3-8 for the hydraulic oil pressure test port **(Figure 3-5, (13))** location.



**Figure 3-7**

## FUNCTION TEST

Perform a function test after servicing the marine gear. Be sure the marine gear is filled with oil.

This test can be performed on a bench test rig or in a boat.

If a marine gear oil cooler is not installed, connect a hydraulic hose between the inlet and the outlet of the hydraulic pump case plate.

Required measuring instruments:

- Pressure gauge: 0 to 5 MPa (0 to 750 psi), with connecting thread M10 x 1.0.
- Temperature gauge: 0 to 120°C (0 to 250°F), connecting thread 3/8 - 18 NPTF.

See the *Marine Gear Major Component Locations* on page 3-8 for the hydraulic oil pressure test port (**Figure 3-5, (13)**) and the lube oil temperature sensor port location.

## Required Tests

1. Fluid leaks
2. Noise emission
3. Direction of rotation, LH (Left Hand) / RH (Right Hand)
4. Lube oil temperature
5. Shifting pressure
6. Neutral performance
7. Shifting performance

The function test should be carried out as follows:

No.	Engine Speed	Electric or Mechanical Shift Lever Activated A: Lever is raised B: Lever is lowered	Duration (Minutes)	Test
1	800 - 1000 rpm	Neutral	5	1, 2
2	600 - 800 rpm (idling speed)	A<->B position repeatedly	-	1, 2, 3, 6, 7
3	1500 - 2500 rpm	B position	*	1, 2, 4
4	600 - 800 rpm (idling speed)	A<->B position repeatedly	-	1, 2, 3, 6, 7
5	Idling - maximum speed	A position	-	1, 2, 5**
6	600 - 800 rpm (idling speed)	A->B position	-	1, 2
7	Idling - maximum speed	B position	-	1, 2, 5*

\* At different speeds.

\*\* Until oil temperature of 75 - 80°C (167 - 176°F) has been reached.

Note: See the Shifting Pressure on page 3-12 and the Standard Performance Values below.

### Standard Performance Values

Perform all the measurements with the oil cooler bypassed.

Items			KMH61V	Remarks
Neutral Performance (Duration Until the Propeller Stops Turning)			≤ 20 seconds	Oil Temperature 30°C (86°F) Idling Speed
Shifting	Time to Engage		≤ 1.0 seconds	Oil Temperature 30°C (86°F) Idling Speed
Oil Temperature			≤ 90°C (194°F)	—
Oil Pressure	Hydraulic Oil Pressure	Maximum	4.82 MPa (699 psi)	Oil Temperature 30°C (86°F) 3300 rpm
		Standard	4.38 ± 0.05 MPa (635 ± 7 psi)	Oil Temperature 60°C (140°F) 3300 rpm
		Minimum	2.19 MPa (318 psi)	Oil Temperature 60°C (140°F) 700 rpm
	Lubricating Oil Pressure	Maximum	0.30 MPa (44 psi)	Oil Temperature 30°C (86°F) 3300 rpm
		Standard	0.25 ± 0.05 MPa (36 ±7 psi)	Oil Temperature 60°C (140°F) 3300 rpm
		Minimum	0.01 MPa (1.5 psi)	Oil Temperature 60°C (140°F) 700 rpm

## Section 4

# SERVICE

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## INTRODUCTION

This section of the *Service Manual* describes the procedures for proper repair of the marine gear.

## BEFORE YOU BEGIN SERVICING

### DANGER

#### Crush Hazard



Always use the lifting equipment with sufficient capacity to lift the marine gear.

NEVER stand under the hoisted marine gear. If the hoist mechanism fails, the marine gear will fall on you, causing serious injury or death.

NEVER support the marine gear with equipment not designed to support the weight of the marine gear such as wooden pieces, blocks or by only using a jack.

**⚠ WARNING****Sudden Movement Hazard**

When you install the “emergency nut” the boat will move forward as soon as you start the engine! Make sure the area is clear before you start the engine.

**Sever Hazard**

NEVER wear jewelry, unbuttoned cuffs, ties or loose-fitting clothing and ALWAYS tie long hair back when working near moving / rotating parts such as the flywheel or the PTO shaft. Keep hands, feet and tools away from all moving parts.

To prevent accidental equipment movement, NEVER start the engine in gear.

Before starting the engine, ALWAYS make sure that all bystanders are clear of the area.

Keep children and pets away while the engine is operating.

Always remove any tools or shop rags used during maintenance from the area before operation.

NEVER service the marine gear while under tow or if the engine is running at idle speed. The propeller may rotate under these circumstances.

Stop the engine before you begin to service the marine gear and secure the propeller so it will not turn.

**Entanglement Hazard**

NEVER leave the key in the key switch when you are servicing the engine or marine gear. Someone may accidentally start the engine and not realize you are servicing it.

Avoid unexpected equipment movement. Shift the marine gear into the NEUTRAL position any time the engine is at idle.

**Electrical Shock Hazard**

ALWAYS turn off the battery switch (if equipped) or disconnect the negative (-) battery cable before servicing the equipment.

ALWAYS keep the electrical connectors and the terminals clean. Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors.

**⚠ CAUTION**

NEVER permit anyone to install or operate the marine gear without proper training. The safety signs and the labels are additional reminders for safe service and maintenance techniques.

Read and understand this *Service Manual* before you operate or service the marine gear to ensure that you follow safe servicing practices and maintenance procedures.

**Slipping and Tripping Hazard**

Ensure that adequate floor space is set aside for servicing the marine gear. The floor space must be flat and free of holes.

Keep the floor free of dust, mud, spilled liquids and parts to help prevent slipping and tripping.

**Tool Hazard**

ALWAYS keep the electrical connectors and the terminals clean. Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors.

**NOTICE**

NEVER engage the starter motor while the engine is running. Damage to the starter motor pinion and / or the ring gear will result.

Always tighten the components to the specified torque. Loose parts can cause equipment damage or cause it to operate improperly.

Only use the replacement parts specified. Other replacement parts may affect the warranty coverage.

NEVER attempt to modify the marine gear's design or the safety features.

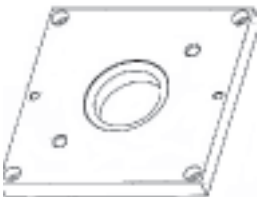
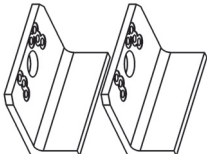


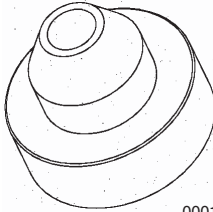

Failure to comply may impair the marine gear's safety and performance characteristics and shorten the marine gear's life. Any alterations to this marine gear may affect the warranty coverage of your marine gear.

## MAINTENANCE HISTORY

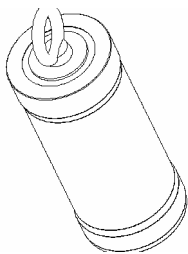
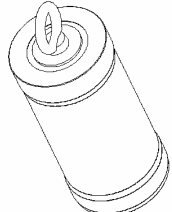
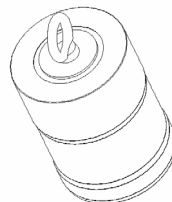

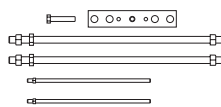
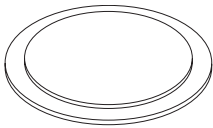
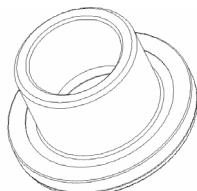
For precise, high-quality operation, preparation is necessary. Check the customer management file for the past performance of the engine and the marine gear.

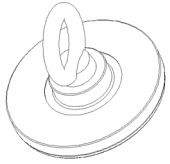
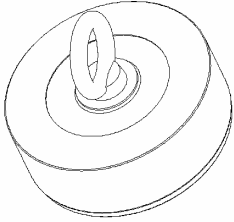
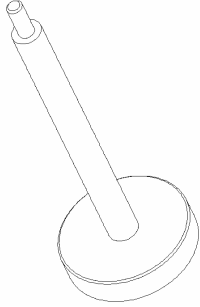
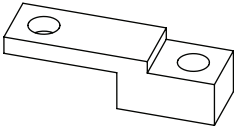
- When was the last maintenance done?
- How much has the marine gear been used (length of time / hours of use) since the last maintenance work?
- What problems were found at the last inspection, and what maintenance work was performed?
- Are the parts needed for replacement during the maintenance on hand?
- Is there a check sheet for the maintenance work?

## SPECIAL SERVICE TOOLS

No.	Tool Name	Applicable model and tool size	Illustration
1	Base (For Disassembly of the Shaft Assembly)	Part No. 177524-09210	 0001977
2	Repair Stand	Part No. 177524-09110	 0004234
3	Spacer A	Part No. 177524-09320	 0001979
4	Spring Compression Tool	Part No. 177524-09310	 0001980
5	Shaft Stand	Part No. 177524-09240	 0001981
6	Spacer B	Part No. 177524-09330	 0001982

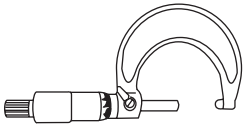
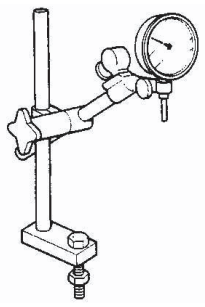
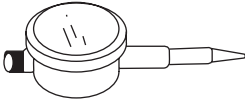
No.	Tool Name	Applicable model and tool size	Illustration
7	Bearing Extractor (For the Bearing and the Collar on the Engine Side)	Part No. 177524-09350	 0001983
8	Thrust Collar Extractor (For the Collar on the Propeller Side)	Part No. 177524-09380	 0001984
9	Flange Stabilizing Wrench (For the Output Coupling)	Part No. 177534-09160	 0005582
10	Master Case A (For the Shim Adjustment of Case A)	Part No. 177534-09610	
11	Master Case B (For the Shim Adjustment of Case B)	Part No. 177534-09630	
12	Master Case B (Idle/Output) (For the Shim Adjustment of Case B)	Part No. 177534-09650	

No.	Tool Name	Applicable model and tool size	Illustration
13	Master Case A (Input Shaft) (For the Shim Adjustment of the Input and the Support Shaft) D72 X L164.5	Part No. 177534-09710	
14	Master Case A (Idle Shaft) (For the Shim Adjustment of the Idle Shaft) D80 X L162.3	Part No. 177534-09730	
15	Master Case A (Output Shaft) (For the Shim Adjustment of the Output Shaft) D100 X L134.2	Part No. 177534-09750	
16	Return Spring Compression Tool (For the Assembly of the Shaft Assembly)	Part No. 177524-09010	 0003502
17	Arm Kit (For the Disassembly of the Shaft Assembly)	Part No. 177524-09200	 0003503
18	Protector (For the Disassembly of the Bearing Cup)	Part No. 177524-09710	 0003504
19	Master Case B (Input Shaft) (For the Shim Adjustment of the Input Shaft and the Support Shaft)	Part No. 177534-09770	






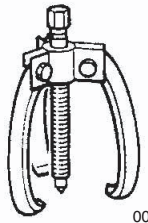

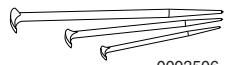
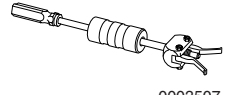
No.	Tool Name	Applicable model and tool size	Illustration
20	Master Case B (Idle Shaft) (For the Shim Adjustment of the Idle Shaft)	Part No. 177534-09780	
21	Master Case B (Output Shaft) (For the Shim Adjustment of the Output Shaft)	Part No. 177534-09800	
22	Stand Case A (For the Shim Adjustment)	Part No. 177533-09850	
23	Output Shaft Locking Tool (For the Shim Adjustment)	Part No. 177534-09860	



## MEASURING INSTRUMENTS

No.	Instrument Name	Application	Illustration
1	Micrometer	Measuring the gauge from 0-25 mm. Accuracy of the reading 1/100 mm	 0000834
2	Dial Indicator Gauge	Dial the indicator gauge with the arm-type support	 0001993
3	Dial Gauge	—	 0000831

## STANDARD TOOLS

No.	Tool Name	Application	Illustration
1	Wrench	For the hexagon bolts (8 mm, 12 mm, 14 mm, 17 mm, 24 mm)	 0001994
2	Allen Wrench	(6 mm, 8 mm)	 0001995
3	Hexagon Socket Wrench	(12 mm, 13 mm, 17 mm, 24 mm, 30 mm)	 0001996
4	Torque Wrench	Adjustable up to 450 N·m	 0001997
5	Plastic Hammer (1000 g) and a Sturdy Screwdriver	—	 0001998
6	3-Jaw Puller	Minimum diameter of 130 mm	 0001999
7	Hexagon Bit Sockets	(6 mm, 8 mm)	 0002910
8	Rolling Head Pry Bars	—	 0003506
9	Slide Hammer Bearing Puller	—	 0003507

## TORQUE CHARTS

### Standard Torque Values

	M6x1.0	M8x1.25	M10x1.25 or 1.5	M12x1.25 or 1.5	M14x1.5	M16x1.5
Cast Iron or Steel	10.8 ± 1.0 N·m 8.0 ± 0.8 ft-lb	25.5 ± 2.0 N·m 18.8 ± 1.5 ft-lb	49.1 ± 4.9 N·m 36.2 ± 3.6 ft-lb	88.3 ± 10.0 N·m 65.1 ± 7.4 ft-lb	137.2 ± 4.9 N·m 101.2 ± 3.6 ft-lb	225.4 ± 10.0 N·m 166.2 ± 7.4 ft-lb
Aluminum	8.8 ± 1.0 N·m 6.5 ± 0.8 ft-lb	20.6 ± 2.0 N·m 15.2 ± 1.5 ft-lb	39.2 ± 2.0 N·m 28.9 ± 1.5 ft-lb	70.6 ± 4.9 N·m 52.1 ± 3.6 ft-lb	109.8 ± 4.9 N·m 81.0 ± 3.6 ft-lb	180.3 ± 10.0 N·m 133.0 ± 7.4 ft-lb

### Torque Specifications

Item	Size	Torques		Comments
Shift Lever Bolt	M10x1.5	39.2 ± 2.0 N·m	28.9 ± 1.5 ft-lb	—
Tapered Plugs	NPTF 3/8	39.2 ± 2.0 N·m	28.9 ± 1.5 ft-lb	Do not use sealing tape
Drain Plugs	M16x1.5	29.4 ± 2.0 N·m	21.7 ± 1.5 ft-lb	—
Neutral Safety Switch	M12x1.25	3.2 ± 2.0 N·m	2.4 ± 1.5 ft-lb	—
Hose for Cooler	3/4 - 16	49 ± 0.49 N·m	36.1 ± 0.36 ft-lb	—
Marine Gear Assembly Bolts	M8	18.6 - 22.6 N·m	13.7 - 16.7 ft-lb	—
	M10	37.2 - 41.2 N·m	27.5 - 30.4 ft-lb	—
	M12	65.7 - 75.5 N·m	48.5 - 55.7 ft-lb	—
Dipstick	—	Hand-Tighten		—

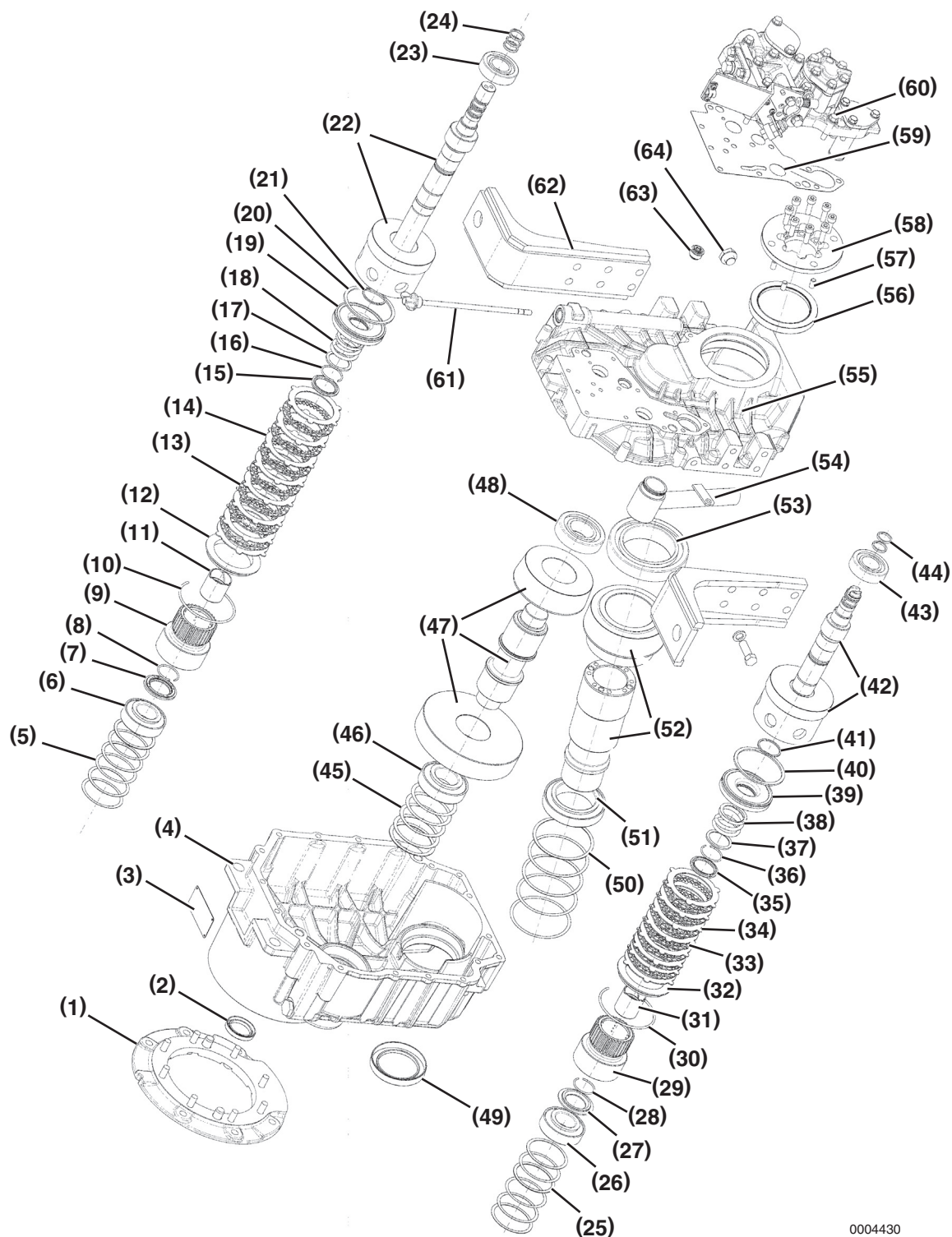
## SEALANTS AND COMPOUNDS

	Description	Application
1	Alvania® Grease or Equivalent *	Assembly of the Oil Seals. Final Assembly of the Cases.
2	Three Bond 1215® or Equivalent **	Mating Surfaces of the Cases.

\* *Alvania® is a registered trademark of Shell Lubricants.*

\*\* *Three Bond 1215® is a registered trademark of Three Bond Co. LTD.*

## MARINE GEAR COMPONENTS

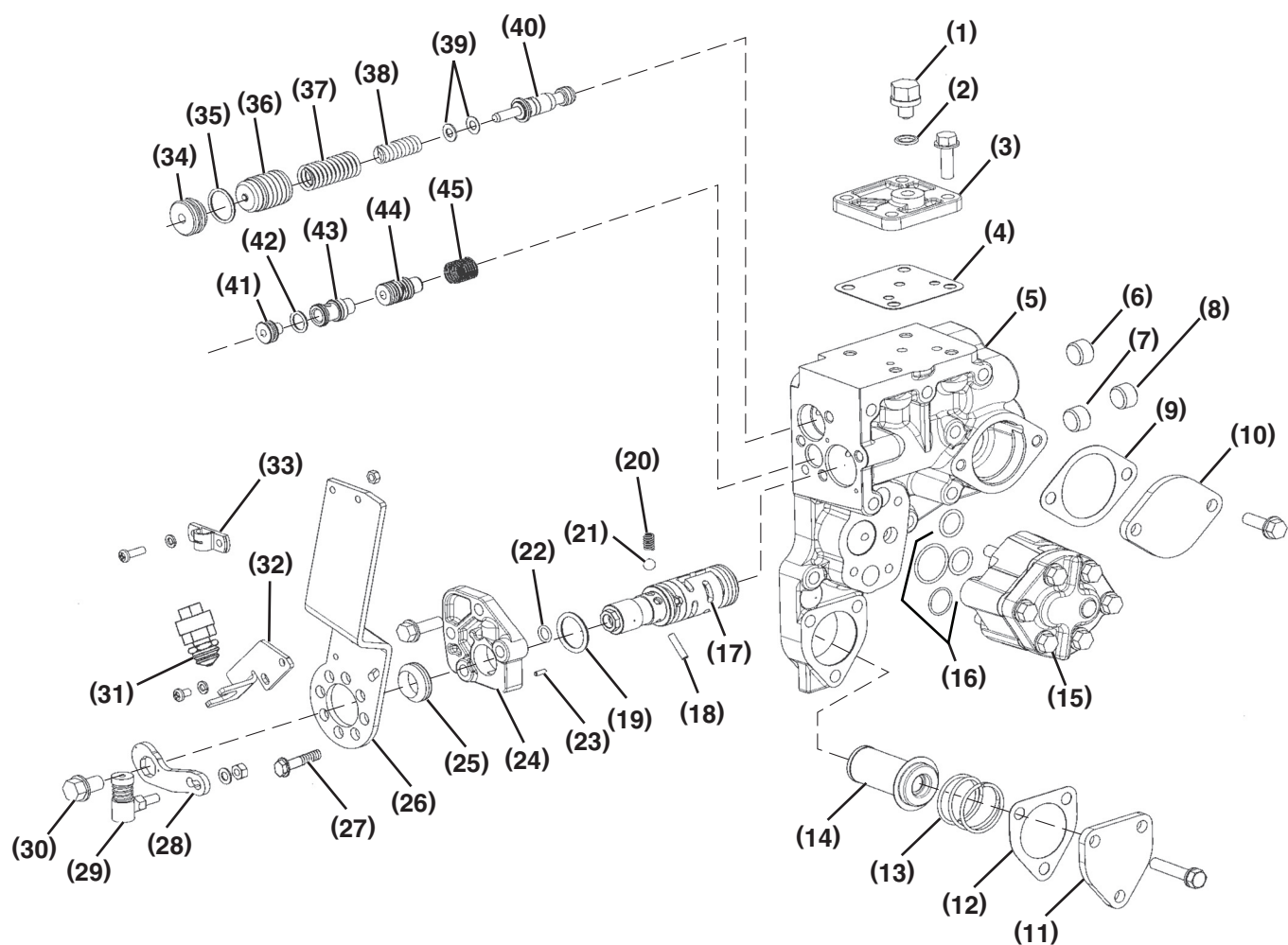


0004430

Figure 4-1

- 1 – Flange Housing
- 2 – Input Shaft Oil Seal
- 3 – Nameplate
- 4 – Case A (Input Case)
- 5 – Input Shaft (Case A) Shims (0.1, 0.3, 0.5 and 1.0 mm)
- 6 – Input Shaft (Case A) Bearing
- 7 – Input Shaft Bearing Thrust Collar
- 8 – Input Shaft Pinion Gear Retaining Ring
- 9 – Input Shaft Pinion Gear
- 10 – Friction Disc Outer Retaining Ring
- 11 – Input Shaft Pinion Gear Bushing
- 12 – Friction Disc Retainer
- 13 – Friction Clutch Disc
- 14 – Steel Clutch Plate
- 15 – Clutch Piston Thrust Collar
- 16 – Piston Return Spring Retaining Ring
- 17 – Piston Return Spring Retainer
- 18 – Piston Return Spring
- 19 – Clutch Piston
- 20 – Clutch Piston Outer Seal Ring
- 21 – Clutch Piston Inner Seal Ring
- 22 – Input Shaft Assembly
- 23 – Input Shaft (Case B) Bearing
- 24 – Input Shaft - PTO Side Seal Rings
- 25 – Support Shaft (Case A) Shims (0.1, 0.3, 0.5 and 1.0 mm)
- 26 – Support Shaft (Case A ) Bearing
- 27 – Support Shaft Bearing Thrust Collar
- 28 – Support Shaft Pinion Gear Retaining Ring
- 29 – Support Shaft Pinion Gear
- 30 – Friction Disc Outer Retaining Ring
- 31 – Support Shaft Pinion Gear Bushing
- 32 – Friction Disc Retainer
- 33 – Friction Clutch Disc
- 34 – Steel Clutch Plate
- 35 – Clutch Piston Thrust Collar
- 36 – Piston Return Spring Retaining Ring
- 37 – Piston Return Spring Retainer
- 38 – Piston Return Spring
- 39 – Clutch Piston
- 40 – Clutch Piston Outer Seal Ring
- 41 – Clutch Piston Inner Seal Ring
- 42 – Support Shaft Assembly
- 43 – Support Shaft (Case B) Bearing
- 44 – Support Shaft (Oil Pump Side) Seal Rings
- 45 – Idle Shaft (Case A) Shims (0.1, 0.3, 0.5 and 1.0 mm)
- 46 – Idle Shaft (Case A) Bearing
- 47 – Idle Shaft Assembly
- 48 – Idle Shaft (Case B) Bearing
- 49 – Output Shaft (Case A) Oil Seal
- 50 – Output Shaft (Case A) Shims (0.3, 0.4, 0.5 and 1.0 mm)
- 51 – Output Shaft (Case A) Bearing
- 52 – Output Shaft Assembly
- 53 – Output Shaft (Case B) Bearing
- 54 – Oil Supply Pipe
- 55 – Case B (Output Case)
- 56 – Output Shaft (Case B) Oil Seal
- 57 – Output Shaft Coupling Locating Pins
- 58 – Output Shaft Coupling
- 59 – Case Plate Gasket
- 60 – Case Plate
- 61 – Oil Dipstick
- 62 – Mounting Feet
- 63 – Pressure Relief Valve
- 64 – Oil Drain Plug

## CASE PLATE COMPONENTS



0004201A

Figure 4-2

- |  |  |
|--|--|
| 1 – Hydraulic Oil Pressure Test Port Plug                                      | 23 – Shift Valve Cover Plate Locating Pins |
| 2 – O-Ring   | 24 – Shift Valve Cover Plate               |
| 3 – Cover Plate for Optional Trolling Valve                                    | 25 – V-Ring                                |
| 4 – Cover Plate Gasket   | 26 – Shift Cable Bracket                   |
| 5 – Case Plate   | 27 – Shift Valve Cover Bolt                |
| 6 – Oil Cooler Supply Port Plug (Oil to Cooler)                                | 28 – Shift Lever                           |
| 7 – Oil Cooler Return Port Plug (Oil from Cooler)                              | 29 – Shift Cable Ball Joint                |
| 8 – Lubricating Oil Pressure Test Port Plug (Optional Temperature Sensor Port) | 30 – Shift Lever Bolt                      |
| 9 – PTO Cover Plate Gasket   | 31 – Neutral Safety Switch                 |
| 10 – PTO Cover Plate   | 32 – Neutral Safety Switch Bracket         |
| 11 – Oil Strainer Cover  | 33 – Shift Cable Retainer                  |
| 12 – Oil Strainer Gasket   | 34 – Modulation Valve Cover                |
| 13 – Oil Strainer Spring   | 35 – Modulation Valve Cover O-Ring         |
| 14 – Oil Strainer  | 36 – Modulation Valve                      |
| 15 – Oil Pump  | 37 – Outer Spring “B”                      |
| 16 – Oil Pump to Valve Body Seals (O-Rings)                                    | 38 – Inner Spring “A”                      |
| 17 – Mechanical Shift Valve  | 39 – Shims                                 |
| 18 – Spring Pin  | 40 – Modulation Valve Piston               |
| 19 – O-Ring  | 41 – Pressure Relief Valve Cover           |
| 20 – Detent Ball Spring  | 42 – Pressure Relief Valve Cover O-Ring    |
| 21 – Detent Ball   | 43 – Pressure Relief Valve Pilot Valve     |
| 22 – O-Ring  | 44 – Throttle Valve                        |
|  | 45 – Spring                                |

## MARINE GEAR SECTIONAL VIEW

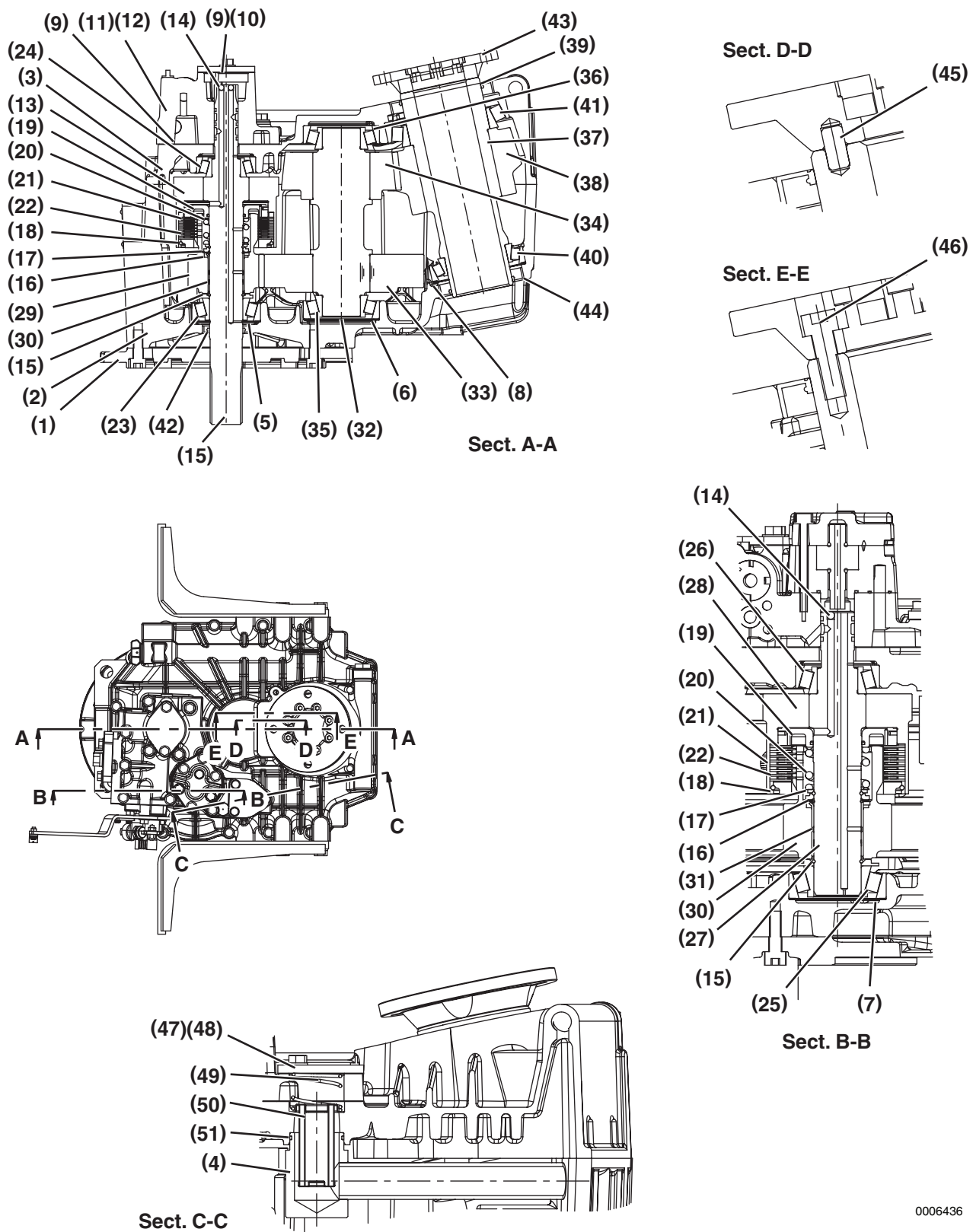


Figure 4-3

0006436



- |                             |                      |
|-----------------------------|----------------------|
| 1 – Mounting Flange         | 27 – Support Shaft   |
| 2 – Case “A”                | 28 – Driven Gear     |
| 3 – Case “B”                | 29 – Input Pinion    |
| 4 – Suction Pipe            | 30 – Bushing         |
| 5 – Shim                    | 31 – Support Pinion  |
| 6 – Shim                    | 32 – Idle Shaft      |
| 7 – Shim                    | 33 – Idle Gear “A”   |
| 8 – Shim                    | 34 – Idle Gear “B”   |
| 9 – PTO Cover               | 35 – Bearing         |
| 10 – Gasket                 | 36 – Bearing         |
| 11 – Case Plate             | 37 – Output Shaft    |
| 12 – Gasket                 | 38 – Output Gear     |
| 13 – Drive Gear             | 39 – Output Coupling |
| 14 – Ball                   | 40 – Bearing         |
| 15 – Thrust Collar “A”      | 41 – Bearing         |
| 16 – Thrust Collar “B”      | 42 – Oil Seal        |
| 17 – Spring Retainer        | 43 – Oil Seal        |
| 18 – Friction Disc Retainer | 44 – Oil Seal        |
| 19 – Cylinder               | 45 – Pin             |
| 20 – Return Spring          | 46 – Bolt            |
| 21 – Friction Disc          | 47 – Strainer Cover  |
| 22 – Steel Plate            | 48 – Gasket          |
| 23 – Bearing                | 49 – Oil Strainer    |
| 24 – Bearing                | 50 – Strainer Spring |
| 25 – Bearing                | 51 – O-Ring          |
| 26 – Bearing                |                      |

## CLUTCH PACK SERVICE

### General Service Information

Prepare for the disassembly of the marine gear as follows. **NOTICE:** *Be sure to replace the parts which upon inspection and measurement are faulty, whose measurements are outside the prescribed limits, or have exceeded the prescribed period of use. The parts which still meet the standard measurements and the prescribed period of use, but which are expected to fall below the standard before the next inspection should also be replaced.*

1. Secure the marine gear on a level base.  
**DANGER! Always use lifting equipment with sufficient capacity to lift the marine gear.**
2. Clean off any dirt, oil or dust on the marine gear with detergent, air or steam. **WARNING! ALWAYS wear eye protection when servicing the marine gear and when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.**

Note: Be careful not to get any dust inside the marine gear during service.

Be sure to use the genuine Yanmar replacement parts for the replacements including the new gaskets, seals, O-rings, piston rings and seal rings.

Use the correct parts and assemble them in the correct manner to the specified standards (tightening torque, adjustment values, etc.).  
Lubricate the bolts and nuts as specified.

Depending upon the placement of the packing, grease the seal packing. Oil or grease the moving parts. Grease the lip of the oil seals.

If necessary, make alignment marks on the parts to make the reassembly easier.

As each part is removed, check its condition and appearance for changes in shape, damage or scratches.

Disassemble the parts in an orderly manner, separating the parts which can be used from those which need to be replaced.

### Clean the Marine Gear

Note: Discard all the gaskets, seals, O-rings, piston rings and seal rings. Replace any part that was damaged during the disassembly.

Use the EPA / OSHA-approved solvents. The parts must be dried and oiled immediately after cleaning. Be sure the parts are free from grit, dirt and abrasives. **WARNING! Always read and follow the safety related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.**

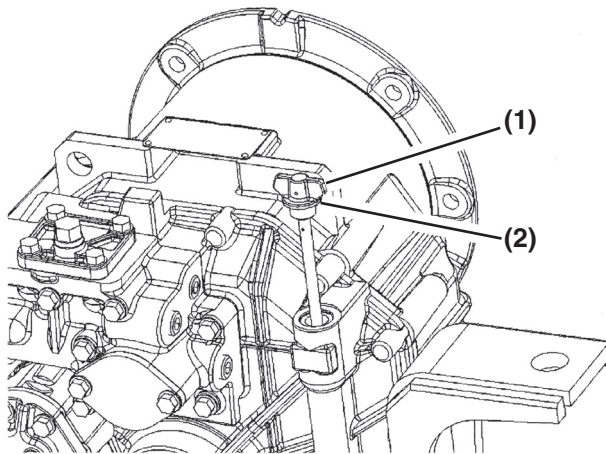
- Only use the clean solvent to flush the valves.
- Be sure to flush all the hoses and the heat exchanger.

Do not remove the packing grease from the new bearings. Thoroughly wash the used bearings. Do not use compressed air to dry the bearings.

Remove all the old sealant from the sealed joints. Thoroughly clean the surfaces to remove the old sealant and the grease.

## Drain the Oil

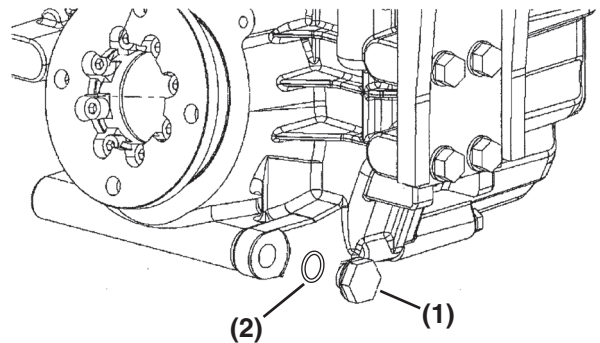
1. **NOTICE:** Prevent dirt and debris from contaminating the oil. Carefully clean the area around the dipstick before removing the dipstick. Remove the oil dipstick (**Figure 4-4, (1)**).
2. Inspect the oil dipstick and the O-ring (**Figure 4-4, (2)**) for damage.



0004426

**Figure 4-4**

3. Position a container under the marine gear to collect the waste oil. Dispose of the waste oil properly. **WARNING! Stay clear of the hot marine gear oil to avoid being burned.**
4. Remove the 24 mm drain plug (**Figure 4-5, (1)**) and the drain plug seal (**Figure 4-5, (2)**).
5. Check the drain seal for damage. Replace if necessary.
6. Inspect the used oil for discoloration, overheating, water contamination or metal shavings.

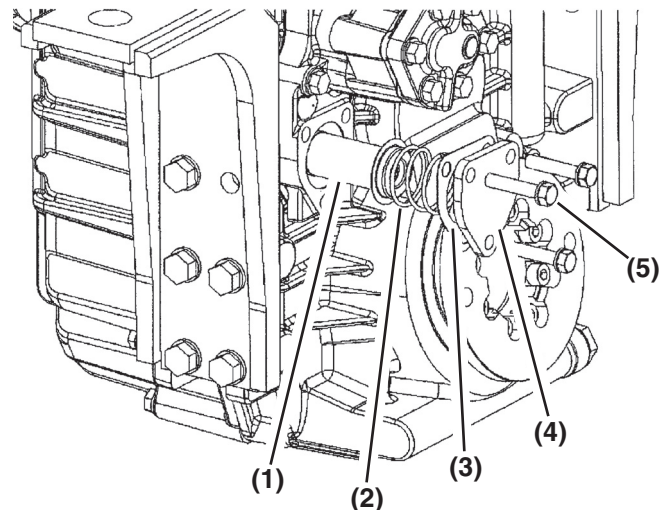


0004427

**Figure 4-5**

## Remove the Oil Strainer

1. Remove the three oil strainer cover M8x40 hex head bolts (**Figure 4-6, (5)**) with a 12 mm socket wrench.
2. Remove the oil strainer cover (**Figure 4-6, (4)**), gasket (**Figure 4-6, (3)**), strainer spring (**Figure 4-6, (2)**) and oil strainer (**Figure 4-6, (1)**).
3. Discard the oil strainer cover gasket.
4. Inspect the oil strainer for damage, inspect for the cause of damage and replace if necessary. If the oil strainer can be reused, it must be washed with clean oil. It is recommended that the oil strainer be cleaned every time the oil is changed.



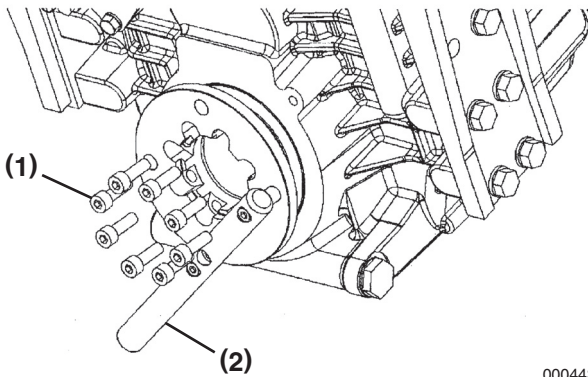
0004428

**Figure 4-6**

1. Install the oil strainer, strainer spring, new gasket and oil strainer cover.
2. Install and tighten the three oil strainer cover hex head bolts. *See Standard Torque Values on page 4-13.*

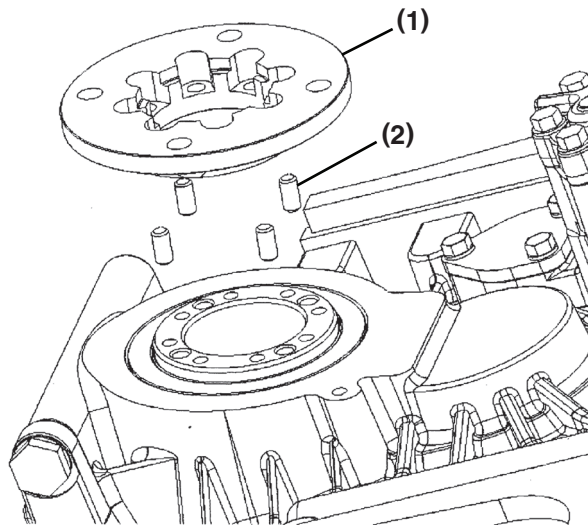
## Remove the Output Coupling

1. Lock the output coupling with a flange stabilizing wrench (**Figure 4-7, (2)**).
2. Remove the eight M12x35 hexagon socket head bolts (**Figure 4-7, (1)**) with a 10 mm Allen wrench.
3. Remove the output coupling (**Figure 4-8, (1)**) and the four pins (**Figure 4-8, (2)**).



0004431

**Figure 4-7**

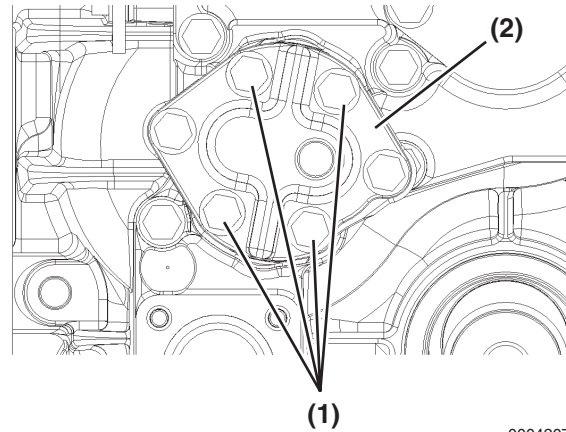


0004432

**Figure 4-8**

## Remove the Hydraulic Oil Pump

1. Remove the four M8x65 hex head bolts (**Figure 4-9, (1)**) with a 12 mm socket wrench.
2. Remove the oil pump (**Figure 4-9, (2)**).

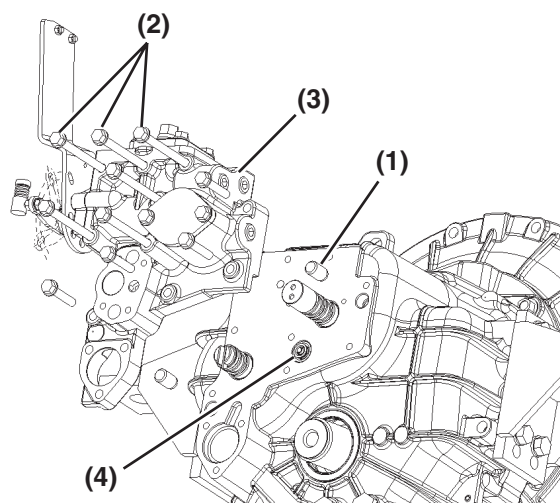


0004207

**Figure 4-9**

## Remove the Case Plate

1. Loosen and remove all 10 of the M8 hex head bolts (**Figure 4-10, (2)**) with a 12 mm socket wrench.
2. Use a plastic hammer to lightly tap the split line of the case plate surface to break the seal.
3. Remove the case plate (**Figure 4-10, (3)**) and the lubricating pressure relief valve (**Figure 4-10, (4)**).
4. Remove all of the parallel pins (**Figure 4-10, (1)**).

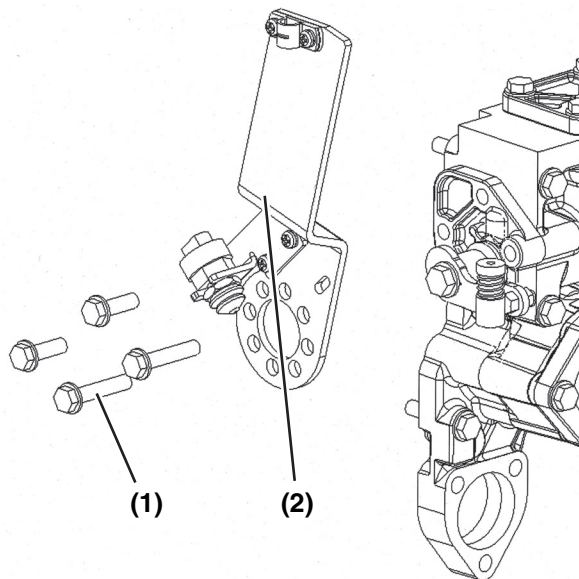


0004208

**Figure 4-10**

## Remove the Valves

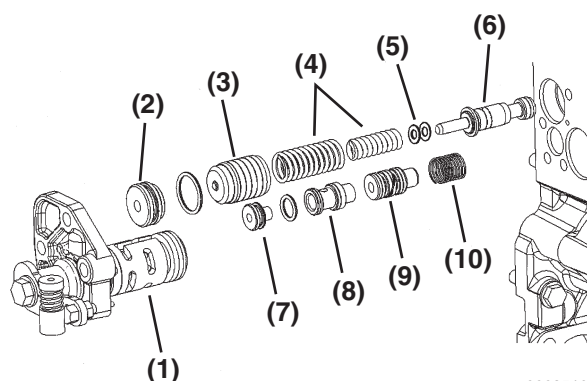
1. Loosen and remove the four hex head bolts (**Figure 4-11, (1)**).
2. Remove the shift cable bracket (**Figure 4-11, (2)**).



0003509

**Figure 4-11**

3. Remove the shifting valve (**Figure 4-12, (1)**).



0003516E

**Figure 4-12**

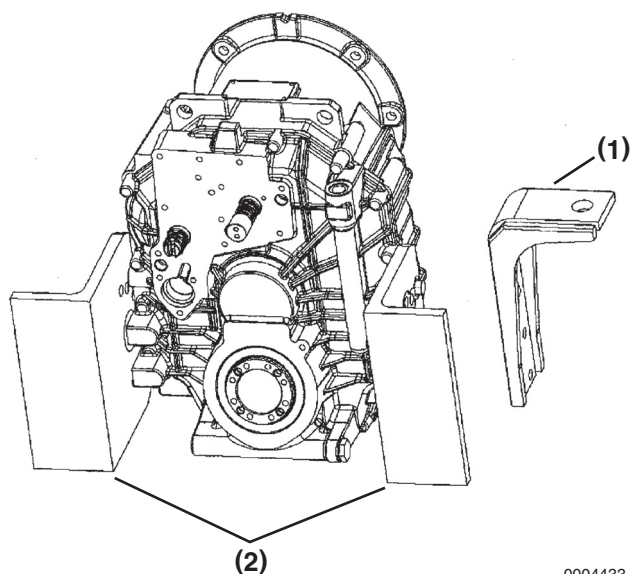
4. Remove the cover for the hydraulic oil relief valve (**Figure 4-12, (2)**) and the O-ring.
5. Remove the modulating valve (**Figure 4-12, (3)**).
6. Remove the springs (**Figure 4-12, (4)**).



7. Remove the hydraulic oil relief valve (**Figure 4-12, (6)**) and the shims (**Figure 4-12, (5)**).
8. Remove the cover for the reducing valve (**Figure 4-12, (7)**) and the O-ring.
9. Remove the pilot valve (**Figure 4-12, (8)**).
10. Remove the throttle valve (**Figure 4-12, (9)**).
11. Remove the spring (**Figure 4-12, (10)**).

### Remove the Mounting Feet

1. Remove the two mounting feet (**Figure 4-13, (1)**). Install the repair stand (**Figure 4-13, (2)**) to the housing.

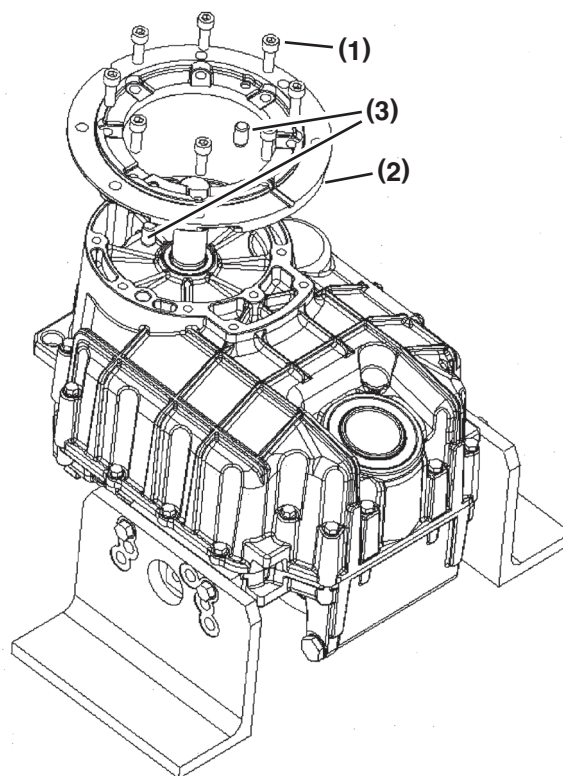


**Figure 4-13**

0004433

### Remove the Mounting Flange

1. Remove all 12 of the M10x35 hexagon socket head bolts (**Figure 4-14, (1)**) with a 8 mm Allen wrench.
2. Remove the mounting flange (**Figure 4-14, (2)**) and the two pins (**Figure 4-14, (3)**).

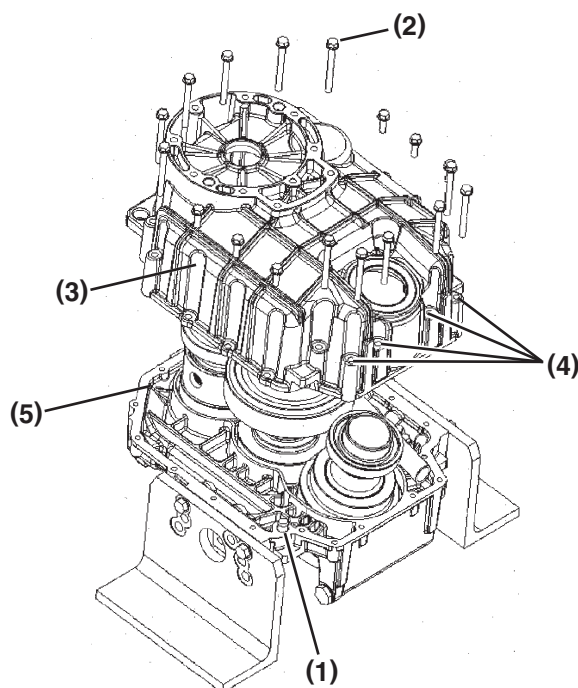


0004434

**Figure 4-14**

## Disassemble the Cases

1. Loosen and remove all 18 of the M8 hex head bolts (**Figure 4-15, (2)**) using both a 12 mm and a 13 mm socket wrench. Note the location of the two recessed bolts near the input shaft and the four stainless steel hex head bolts (**Figure 4-15, (4)**) at the lower end of the housing.



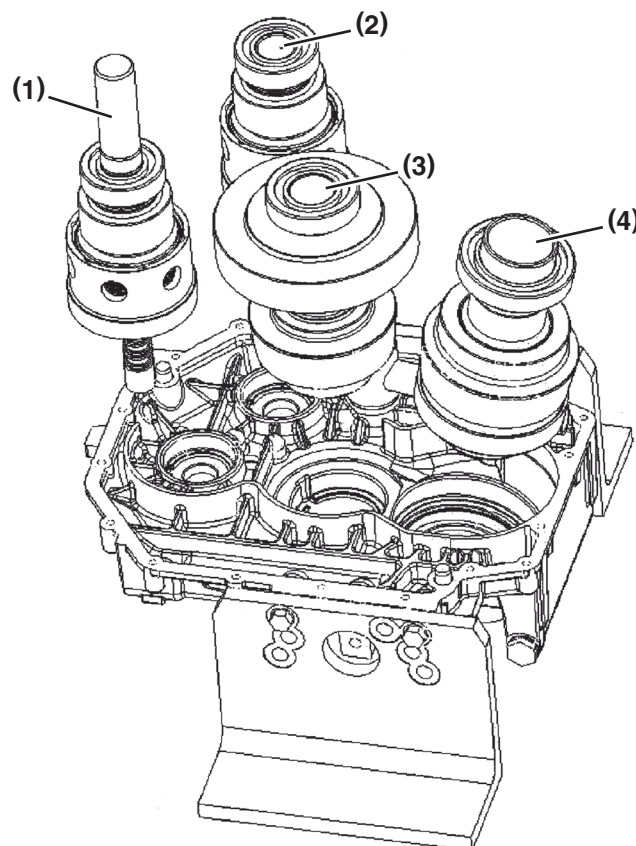
0004435B

**Figure 4-15**

2. Lightly tap case A (**Figure 4-15, (3)**) with a plastic hammer and lift case A from case B (**Figure 4-15, (5)**). *NOTICE: Prying with sharp tools can result in damage to the sealing surface, oil leaks and failure of marine gear.*
3. Remove the parallel pins (**Figure 4-15, (1)**).

## Removal of the Shafts and the Gears

1. Remove the gear set from case B:
  - Input shaft (**Figure 4-16, (1)**) assembly
  - Support shaft (**Figure 4-16, (2)**) assembly
  - Idle shaft (**Figure 4-16, (3)**) assembly
  - Output shaft (**Figure 4-16, (4)**) assembly

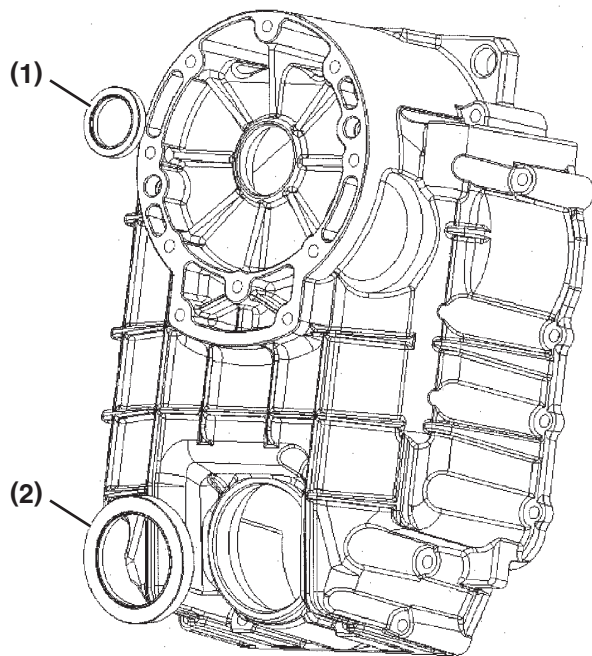


0004437

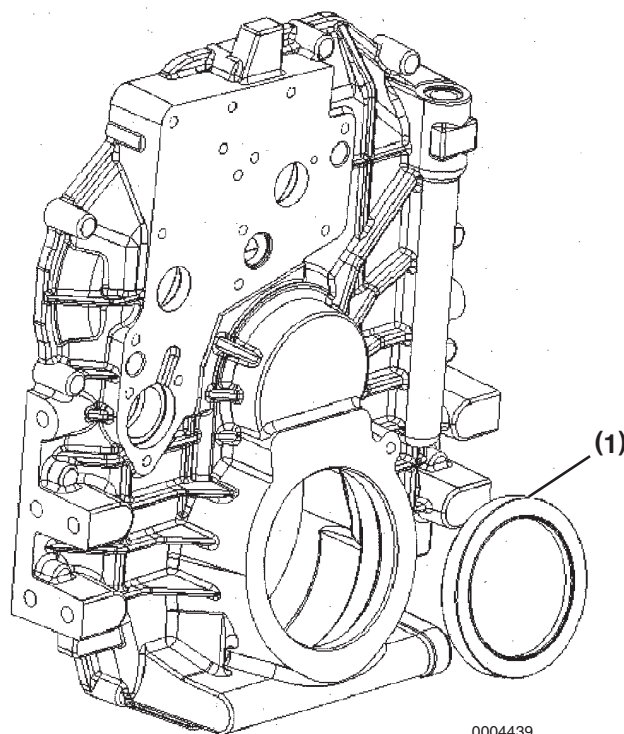
**Figure 4-16**

## Remove the Oil Seals

1. Remove and discard the input oil seal (**Figure 4-17, (1)**) and the output oil seal (**Figure 4-17, (2)**) from case A.
2. Remove and discard the output oil seal (**Figure 4-18, (1)**) from case B.



0004438

**Figure 4-17**

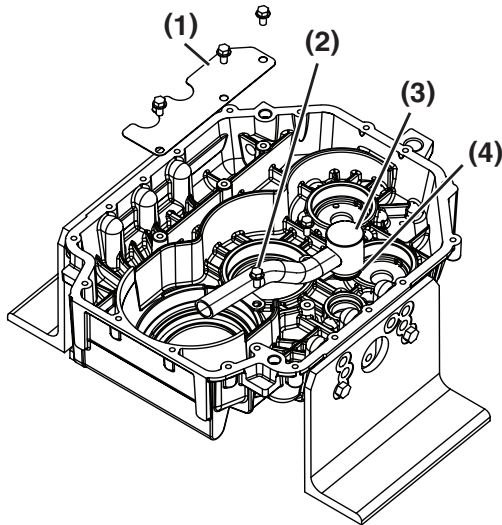
0004439

**Figure 4-18**



**Remove the Oil Suction Pipe and the Plate**

Remove the hex head bolt (**Figure 4-19, (2)**), the oil suction pipe (**Figure 4-19, (3)**). Remove the hex head bolts and the plate (**Figure 4-19, (1)**) from case B.



0005585

**Figure 4-19**

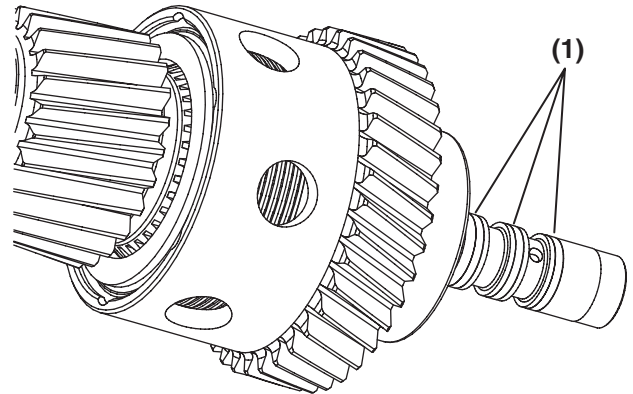
- 1 – Plate
- 2 – Suction Pipe Bolt
- 3 – Oil Suction Pipe
- 4 – O-Ring

**NOTICE:** Be sure to keep dirt out of the housing to avoid damage to the marine gear.

Note: The oil suction pipe and the plate removal is optional.

**Remove the Seal Rings**

Remove the seal rings (**Figure 4-20, (1)**) from the input shaft and the support shaft.



0001943

**Figure 4-20**

## Remove the Tapered Roller Bearings

Check for failed bearings or excessive bearing wear. If the bearings are damaged, replace both the outer bearing race and the inner bearing race.

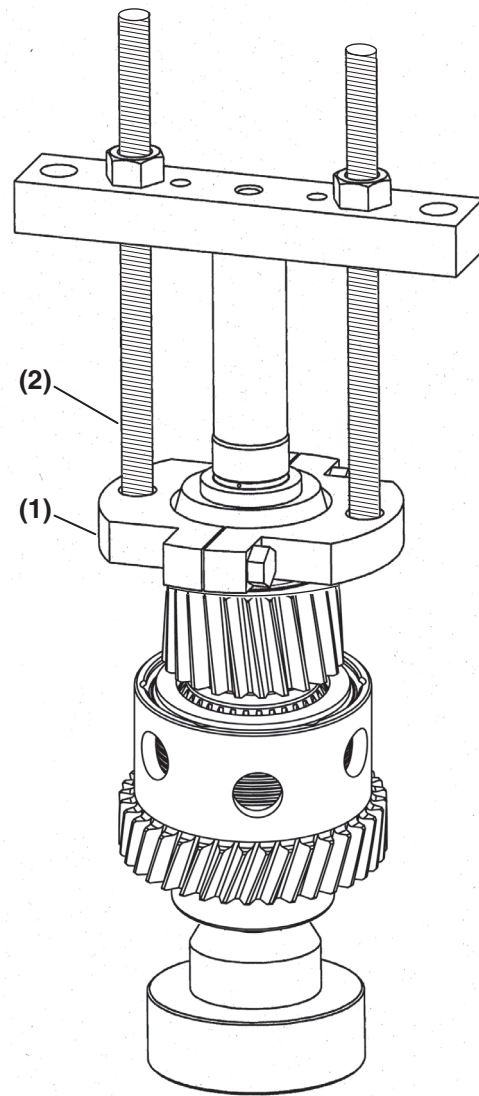
### Remove the Tapered Roller Bearings' Inner Races

#### *Input Shaft and Support Shaft - Engine Side*

Remove the engine side tapered roller bearing inner races with a thrust collar, bearing extractor (**Figure 4-21, (1)**) and an arm and a threaded rod (M16 × 600) (**Figure 4-21, (2)**).

- Be sure to pull on the thrust collar and not on the bearing.

Note: Note the direction that the thrust collar is oriented on the shaft.



0001933

**Figure 4-21**

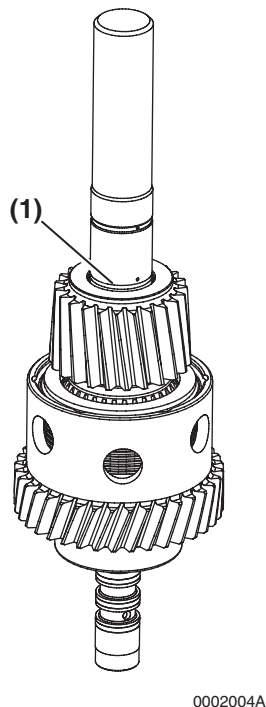
#### *Input Shaft and Support Shaft - Propeller Side*

Do not disassemble the shaft and the clutch housing. If one bearing is damaged, replace the complete bearing set.

## Remove the Clutch Pack

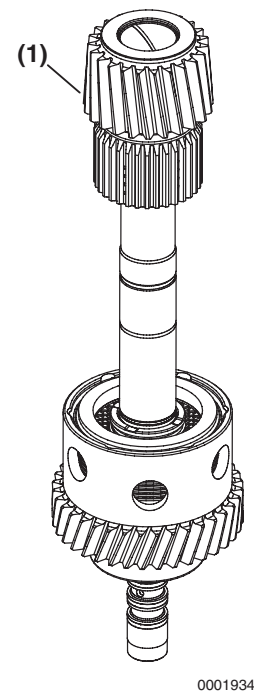
### Remove the Clutch Discs

1. To remove the clutch discs from the input shaft, remove the retaining ring (**Figure 4-22, (1)**).



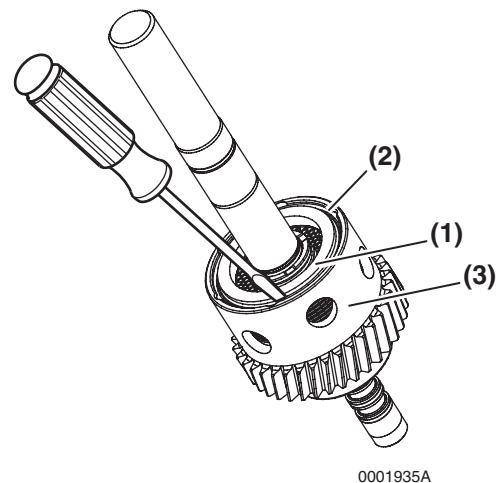
**Figure 4-22**

2. Slide the pinion gear assembly (**Figure 4-23, (1)**) off the input shaft.



**Figure 4-23**

3. Carefully remove the outer retaining ring (**Figure 4-24, (1)**).
4. Remove the friction disc retainer (**Figure 4-24, (2)**).
5. Remove the steel plates and the friction discs from the clutch housing (**Figure 4-24, (3)**).
6. Repeat the same procedure to remove the friction disc retainer from the support shaft.

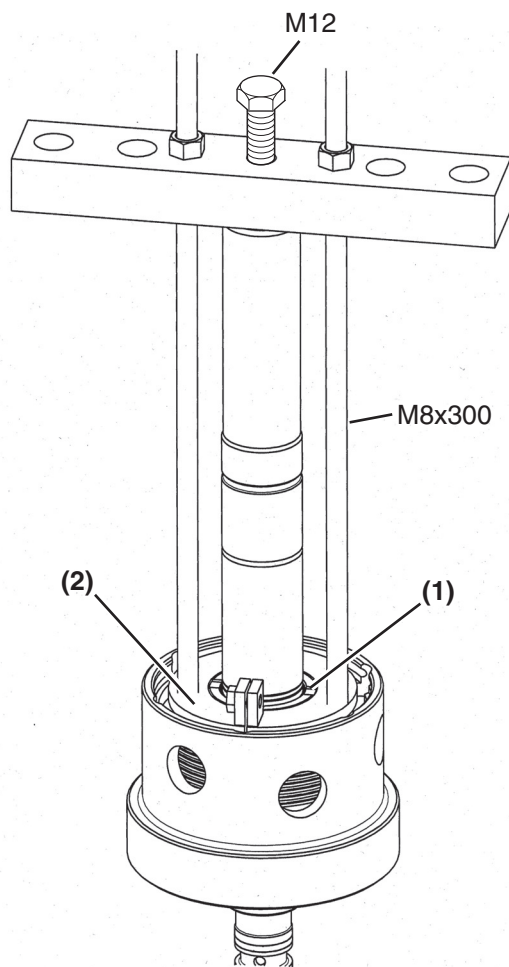


**Figure 4-24**

## Remove the Clutch Pistons

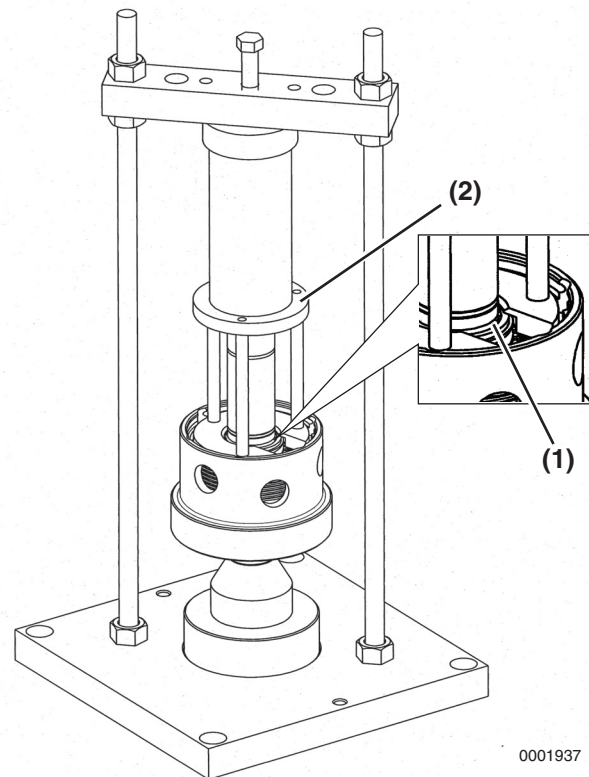
1. To remove the clutch pistons from the input shaft, remove the thrust collar (**Figure 4-25, (1)**) with a thrust collar extractor (**Figure 4-25, (2)**).

Note: Note the direction the thrust collar is oriented on the shaft. The lining must face up.



0001936

**Figure 4-25**



0001937

**Figure 4-26**

2. Use a spring compressor tool (**Figure 4-26, (2)**) to compress the spring no more than 5 mm (0.20 in.).
3. Remove the snap ring (**Figure 4-26, (1)**).

4. Remove the inner retaining ring (**Figure 4-27, (1)**) from the groove.
5. Remove the spring retainer, return spring (**Figure 4-27, (2)**) and hydraulic cylinder (**Figure 4-27, (3)**). This may require application of low pressure air to the opening in the end of the shaft to remove the piston.

Note: Note the direction the retaining ring is installed on the shaft (chamfer facing up).

6. Repeat the procedure for the support shaft.

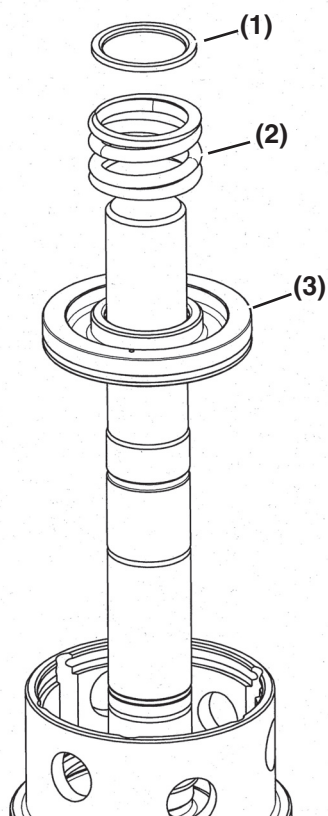


Figure 4-27

## Inspect the Bearings

Replace the bearings that show signs of corrosion and wear such as scoring, scratching, cracking, pitting or chipping.

Replace the bearing if the rotation is not smooth.

Inspect the bearing bores and the shafts for grooves, burrs or galling. Replace the part if the crocus cloth cannot repair the damage.

## Inspect the Shafts and the Gears

Check all the gears, bearings, piston rings on the input shaft and the support shaft for signs of wear or failure.

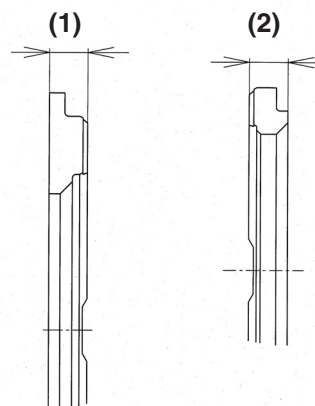
If any of the gears are damaged or showing signs of excessive wear, Yanmar recommends replacing the complete gear set.

To check for the correct clutch operation, rotate the gears on the input shaft.

## Inspect the Friction Discs

Stepped Wear	Standard	Limit
Friction Disc	1.65 - 1.75 mm (0.065 - 0.069 in.)	1.55 mm (0.061 in.)

## Inspect the Thrust Collars



0001942

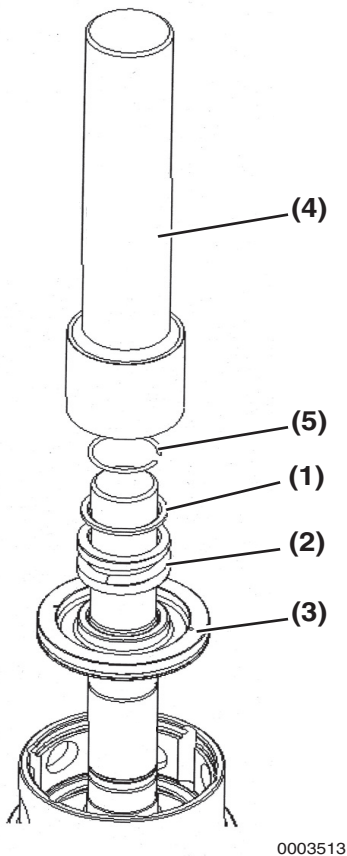
Figure 4-28

Stepped Wear	Standard	Limit
Engine Side (Figure 4-28, (1))	4.85 - 4.95 mm (0.191 - 0.195 in.)	4.65 mm (0.183 in.)
Propeller Side (Figure 4-28, (2))	4.90 - 5.00 mm (0.193 - 0.197 in.)	4.70 mm (0.185 in.)

## Assemble the Input Shaft and the Support Shaft

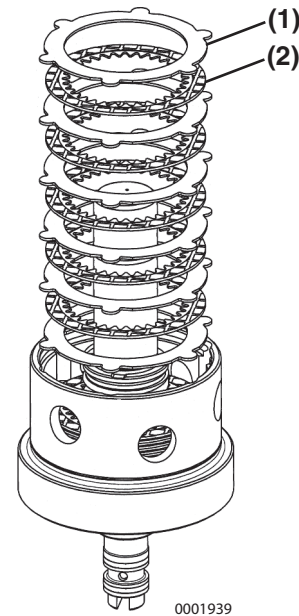
### Reassemble the Friction Assembly

1. Lubricate and install the two new seal rings on the input shaft piston. Do not overstretch the seal rings when installing.
2. Install the piston (**Figure 4-29, (3)**) into the clutch housing, being careful not to damage the seal rings.
3. Install the return spring (**Figure 4-29, (2)**), the inner retaining ring (**Figure 4-29, (1)**) and the snap ring (**Figure 4-29, (5)**) by applying pressure with the return spring compression tool (**Figure 4-29, (4)**). Be sure the inner retaining ring is locked into the second groove on the shaft with the chamfered side facing up.



**Figure 4-29**

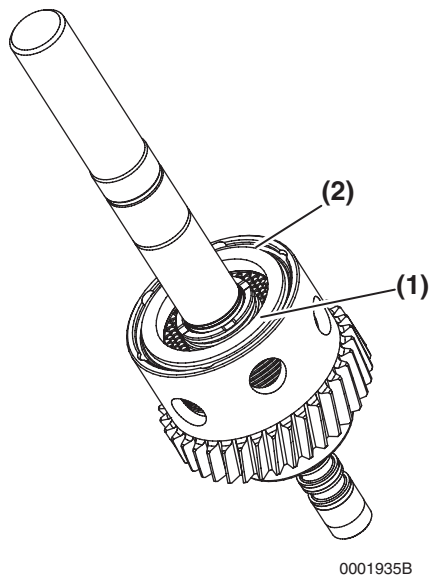
4. Install the thrust collar.
5. Presoak all the friction discs for one hour before the assembly. Then liberally lubricate the steel plates and the friction discs during the assembly. Install the steel plates (**Figure 4-30, (1)**) and the friction discs (**Figure 4-30, (2)**) beginning and ending with a steel plate.



**Figure 4-30**

Note: Refer to the Parts Catalog for exact quantity of the steel plates and the friction discs.

6. Install the friction disc retainer (**Figure 4-31, (1)**). Install and seat the outer retaining ring (**Figure 4-31, (2)**) into the groove on the shaft with the chamfer side of the ring facing up. Check for friction disc retainer alignment and for full engagement.

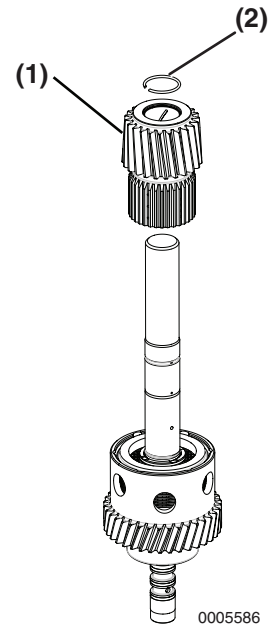


**Figure 4-31**

7. Repeat the procedure for the support shaft.

### Assemble the Pinion Gear Assemblies

1. Lubricate and slide the pinion gear assembly (**Figure 4-32, (1)**) onto the shaft.
2. Secure the pinion gear assembly with the snap ring (**Figure 4-32, (2)**).



**Figure 4-32**

3. Repeat the procedure for the support shaft.

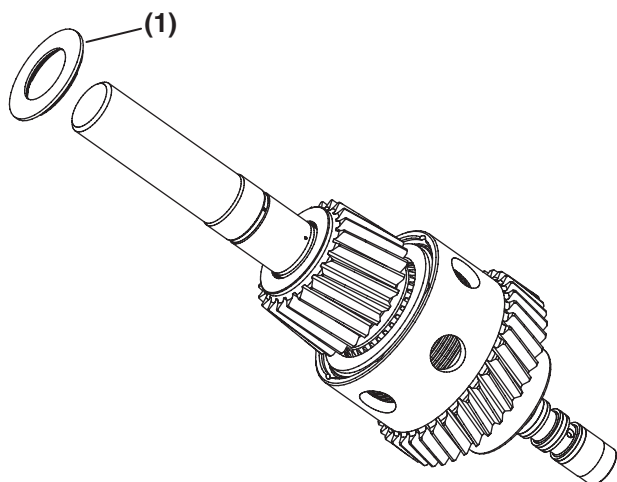


## Assemble the Thrust Collars

### Construction of the Thrust Collars

Shaft-Position	Engine Side	Propeller Side
Input Shaft	Lining	No Lining
Support Shaft	No Lining	Lining

1. Heat the thrust collars to approximately 120°C (250°F). **WARNING! Handle the heated parts with heat-resistant gloves.**
2. Press the thrust collars (**Figure 4-33, (1)**) onto both the input and the support shafts.
3. The engine-side thrust collar must be installed with the lining facing down.
4. The propeller-side thrust collar must be installed with the lining facing up.
5. Make sure the thrust collars are fully pressed on the shafts and have a clearance of 0.15 to 0.95 mm (0.006 to 0.037 in.) between the thrust collar and the top of pinion gear assembly.
6. Verify that the thrust collars are not bent after the installation.

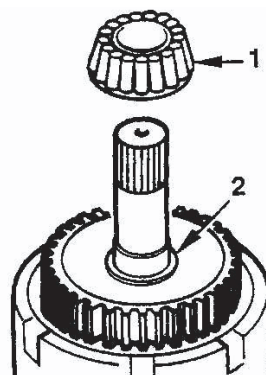


0001941

**Figure 4-33**

## Assemble the Tapered Roller Bearings onto the Input and the Support Shafts

1. Heat the inner race of the tapered roller bearing to approximately 120°C (250°F). **WARNING! Handle the heated parts with heat-resistant gloves.**
2. Carefully press the inner race of the tapered bearing (**Figure 4-34, (1)**) onto the shaft until the inner race contacts the thrust collar (**Figure 4-34, (2)**). Be careful not to damage the roller cage when installing the inner race.



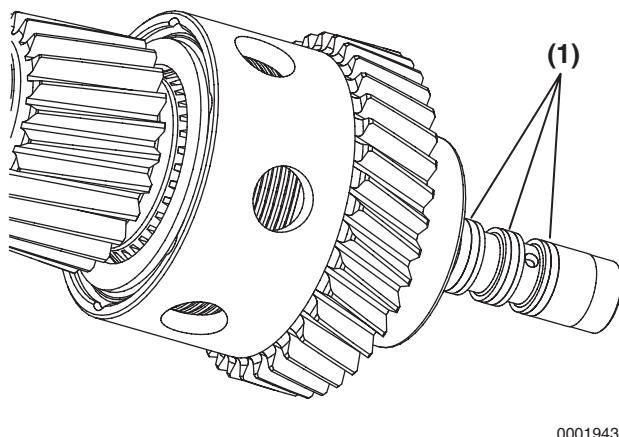
0002005

**Figure 4-34**



## Reassemble the Seal Rings

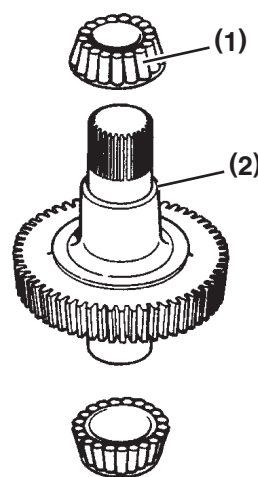
1. Lubricate the seal rings (**Figure 4-35, (1)**) with grease.
2. Install the seal rings onto the input shaft and the support shaft.



**Figure 4-35**

## Reassemble the Tapered Roller Bearing onto the Output Shaft and the Idler Shaft

1. If previously removed, install the tapered roller bearing onto the output shaft.
2. Heat the inner race of the tapered bearing to approximately 120°C (250°F). **WARNING! Handle the heated parts with heat-resistant gloves.**
3. Carefully press the tapered roller bearing inner race (**Figure 4-36, (1)**) onto the output shaft and the idler shaft until the inner race contacts the shoulder of shaft (**Figure 4-36, (2)**).



**Figure 4-36**

## Inspect the Cases

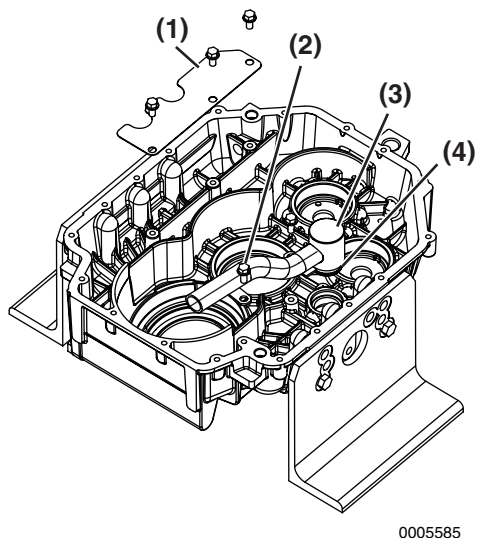
Replace any case that is cracked.

Inspect the machined surfaces and the bores for wear, grooves or scratches. Only use crocus cloth or a soft stone to remove the scratches and the burrs.

Repair any damaged threads using the correct size tap or the thread repair kit.

### Assemble the Oil Suction Pipe and the Plate (If Removed)

1. Install the suction pipe (**Figure 4-37, (3)**), O-ring (**Figure 4-37, (4)**) and plate (**Figure 4-37, (1)**) to case B.
2. Install and tighten the M8 hex head bolt (**Figure 4-37, (2)**) retaining the suction pipe.



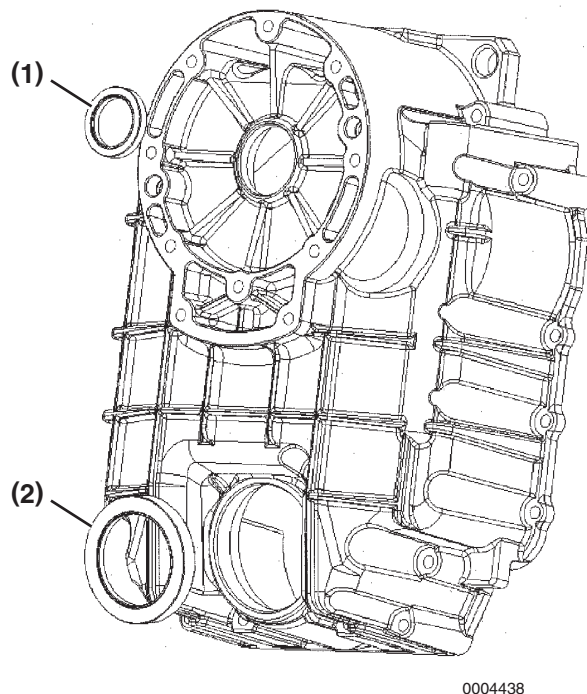
**Figure 4-37**

- 1 – Plate
- 2 – Suction Pipe Bolt
- 3 – Oil Suction Pipe
- 4 – O-Ring

3. Install the plate and hex head bolts.

### Assemble the Oil Seals

1. Apply Shell Alvania Grease™ or equivalent to the lips of the input oil seal (**Figure 4-38, (1)**) and the output oil seals (**Figure 4-39, (1)**), (**Figure 4-38, (2)**).
2. Install the seals until the seals are flush with the cases.



**Figure 4-38**

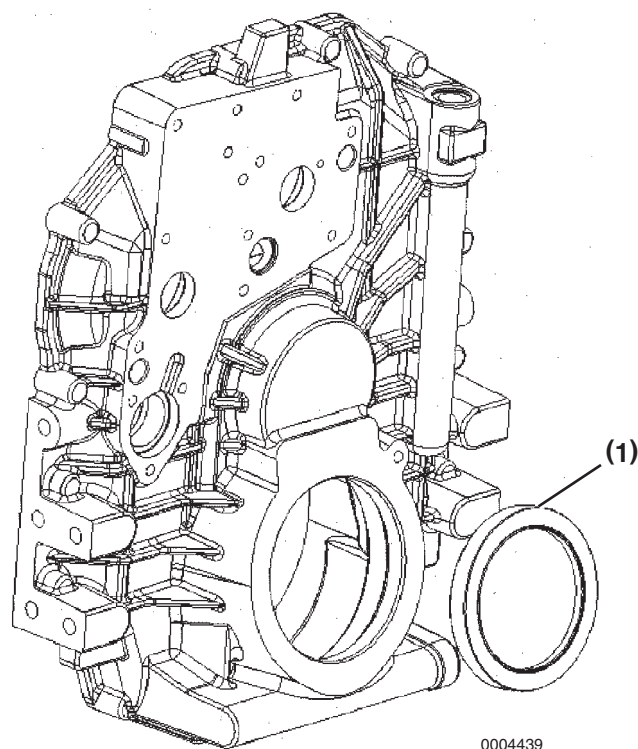


Figure 4-39

### Assemble the Gear Set into the Housing

1. Clean the housing mating surfaces with an oilstone. **NOTICE:** Keep dirt out of the marine gear housing.

### Final Assembly of the Cases

1. Use Shell Alvania Grease™ or equivalent to fill the space between the seal and the dust lips of the shaft seal rings.
2. Apply a thin coat of Threebond™ 1215 or equivalent on the mating face of case B (**Figure 4-40, (1)**).
3. Install the parallel pins (**Figure 4-40, (2)**) with the large chamfer end facing up.

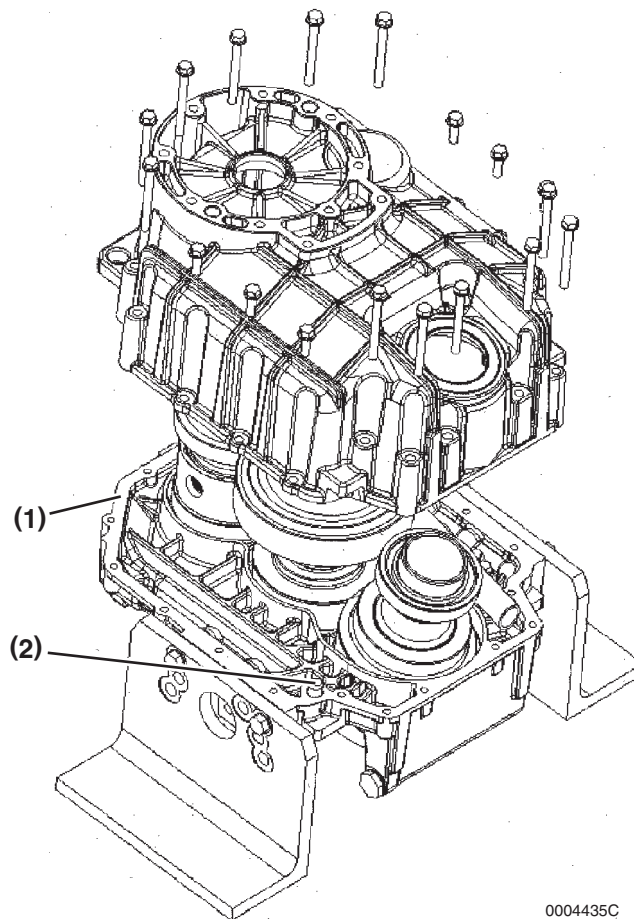
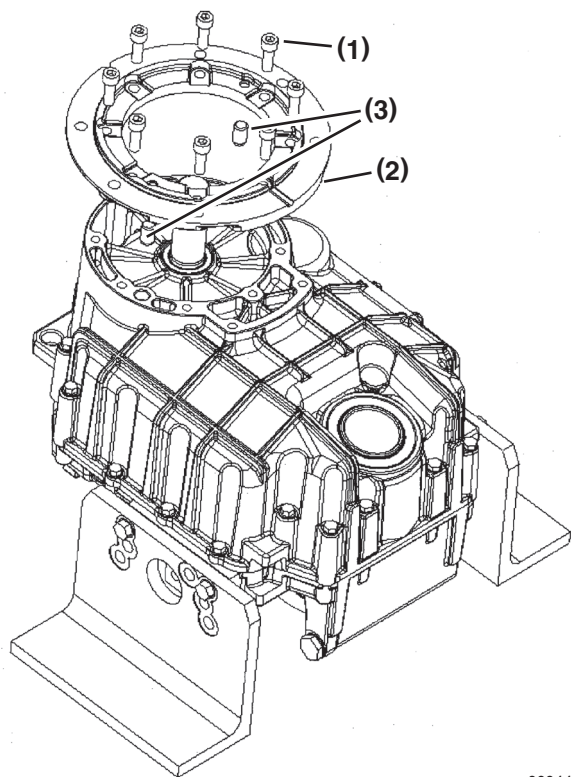


Figure 4-40

4. Install case B.
5. Install and tighten the 18 M8 hex head bolts.

## Assemble the Mounting Flange

1. Install the parallel pins (**Figure 4-41, (3)**).
2. Install the mounting flange (**Figure 4-41, (2)**).
3. Install the 12 M10x35 hexagon socket head bolts (**Figure 4-41, (1)**).

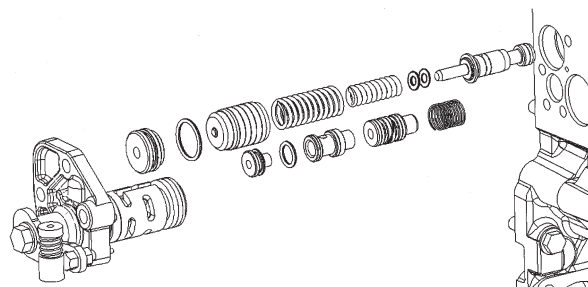


0004434

**Figure 4-41**

## Assemble the Valves

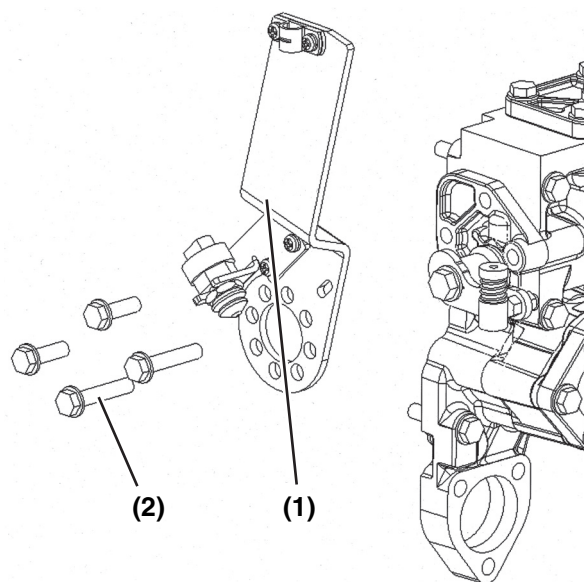
1. Install the valves into the case plate (**Figure 4-42**).



0003516

**Figure 4-42**

2. If necessary, adjust the shifting pressure by increasing or decreasing the shims (increasing the shim thickness by 0.1 mm [0.0039 in.], shifting pressure will rise by approximately 0.7 MPa [101.5 psi]).
3. Install the shift cable bracket (**Figure 4-43, (1)**).



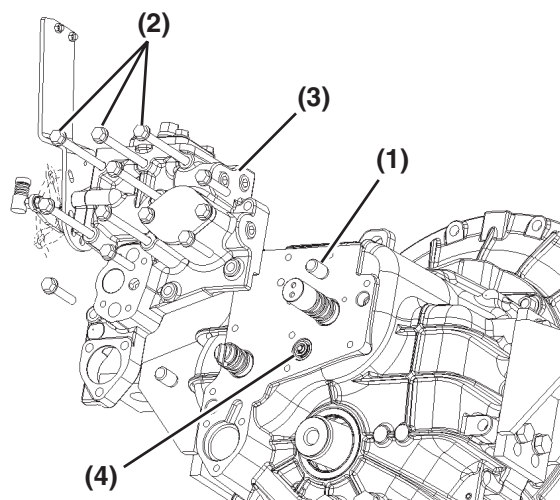
0003517

**Figure 4-43**

4. Install and tighten the four hex head bolts (**Figure 4-43, (2)**).

## Assemble the Case Plate

1. Remove the repair stand and install the mounting feet (**Figure 4-13, (1)**). Tighten the M12x35 hex head bolts to the specified torque.
2. Install the parallel pins (**Figure 4-44, (1)**) with the large chamfer end facing the case plate.
3. Place the lubricating pressure relief valve (**Figure 4-44, (4)**) in the housing.
4. Install a new gasket on the housing (**Figure 4-44, (3)**).
5. Slide the case plate carefully onto the input shaft and the support shaft.
6. Install and tighten the hex head bolts (**Figure 4-44, (2)**) to the specified torque.

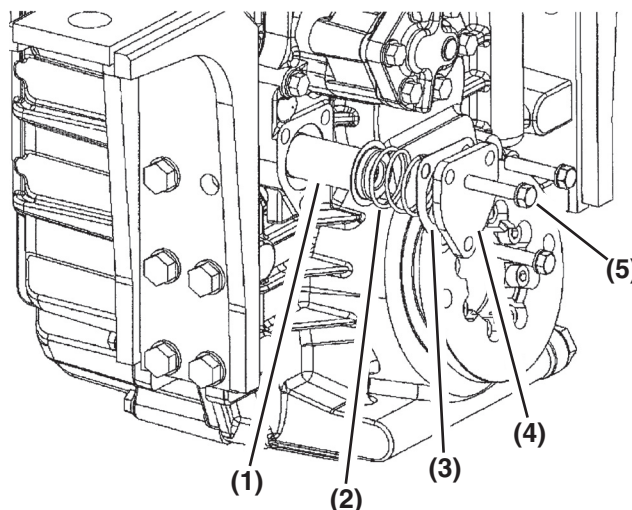


0004208

**Figure 4-44**

## Install the Oil Strainer

1. Check the seal for damage and the strainer for wear. Replace if necessary.
2. Wash the oil strainer (**Figure 4-45, (1)**) with clean oil whenever the oil is changed.
3. Install the strainer, spring (**Figure 4-45, (2)**), gasket (**Figure 4-45, (3)**) and cover (**Figure 4-45, (4)**) with the three M8x40 hex head bolts (**Figure 4-45, (5)**).



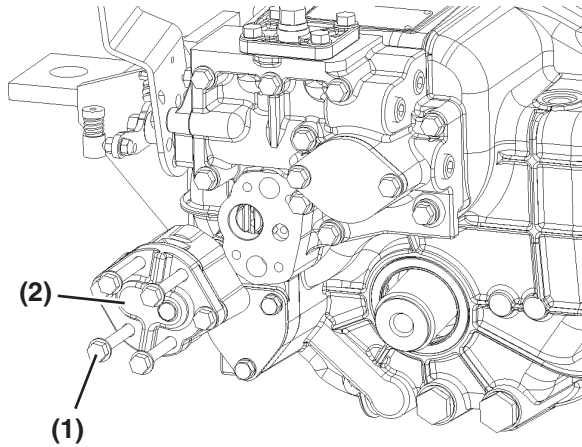
0004428

**Figure 4-45**



## Install the Hydraulic Oil Pump

1. Install the oil pump with the O-rings (**Figure 4-46, (2)**).
2. Install the four M8x65 hex head bolts (**Figure 4-46, (1)**).

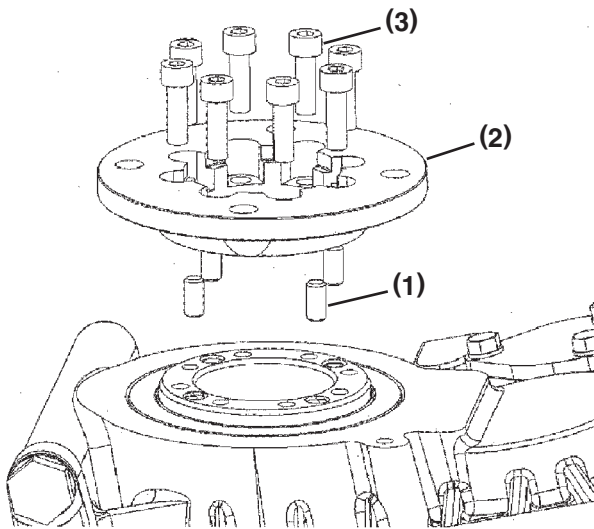


0004230

**Figure 4-46**

## Install the Output Coupling

1. Install the parallel pins (**Figure 4-47, (1)**).
2. Install the output coupling (**Figure 4-47, (2)**).
3. Install the eight M8x25 hexagon socket head bolts (**Figure 4-47, (3)**).



0004453

**Figure 4-47**

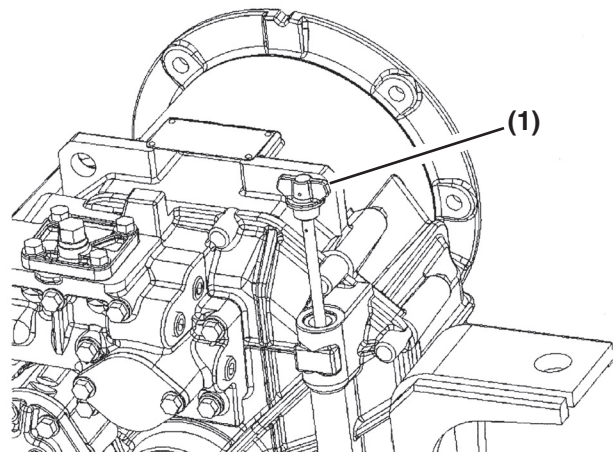
## Fill the Marine Gear with Oil

1. Fill the marine gear with oil and add the amount required for the cooler and the pipelines.
2. Install the oil cap and hand-tighten. Over-tightening may damage the cap.
3. Check the oil level.

## Checking the Oil Level

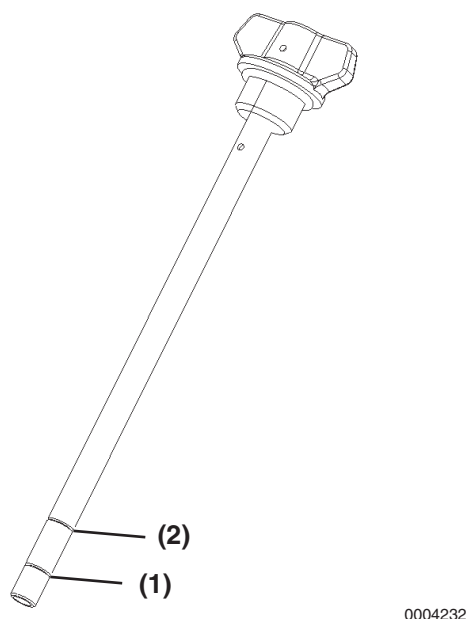
Always check the oil level before operating the marine gear. The marine gear oil level may be checked in cold or hot condition.

1. Remove the dipstick (**Figure 4-48, (1)**) and wipe with a clean cloth. *NOTICE: Prevent dirt and debris from contaminating the marine gear oil. ALWAYS clean the oil cap / dipstick and the surrounding area before you remove the cap.*
2. Insert the dipstick into the oil fill port but do not thread it in.
3. Remove the dipstick. The oil level should be between the upper (**Figure 4-49, (2)**) and the lower (**Figure 4-49, (1)**) lines on the dipstick.
4. Fully reinsert and thread the dipstick into the oil fill port.



0004426B

**Figure 4-48**

**Figure 4-49**

5. Move the shift lever to the NEUTRAL position.
6. Start the engine. Let the engine run at idle with the shift lever in the NEUTRAL position for several minutes. This will ensure the oil is distributed to all the pipelines, oil cooler and marine gear oil passages. **NOTICE: NEVER hold the key in the START position for longer than 15 seconds or the starter motor will overheat.**
7. Stop the engine. WAIT AT LEAST 10 MINUTES for the oil to drain back into the sump. **NOTICE: Never overfill the marine gear. After you add marine gear oil, run the engine for several minutes and shut it down. Wait at least 10 minutes to check the marine gear oil level. This allows the oil to drain back into the sump, otherwise, you may overfill the marine gear with oil.**
8. Check the oil level. If necessary, add oil until the level reaches the upper mark on the dipstick. **NOTICE: Only use the marine gear oil specified. Other marine gear oils may affect the warranty coverage, cause the internal marine gear components to seize and / or shorten the marine gear life. NEVER mix different types of marine gear oil. This may adversely affect the lubricating properties of the marine gear oil. Check the oil level again after operating the marine gear for a short period of time.**

## GEAR SHIMMING ADJUSTMENT

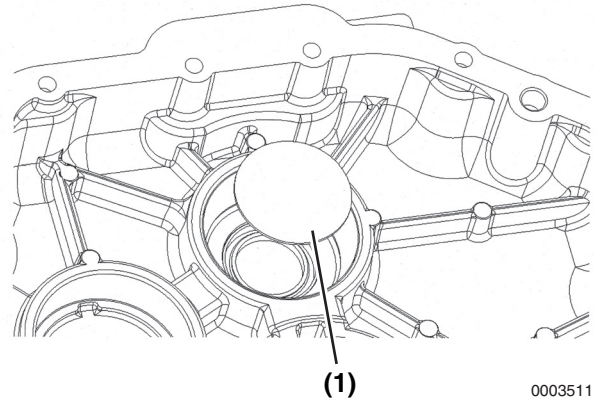
Note: Gear shimming is only required when a gear ratio is changed or a gearshaft assembly or main case is replaced.

### Remove the Bearing Races

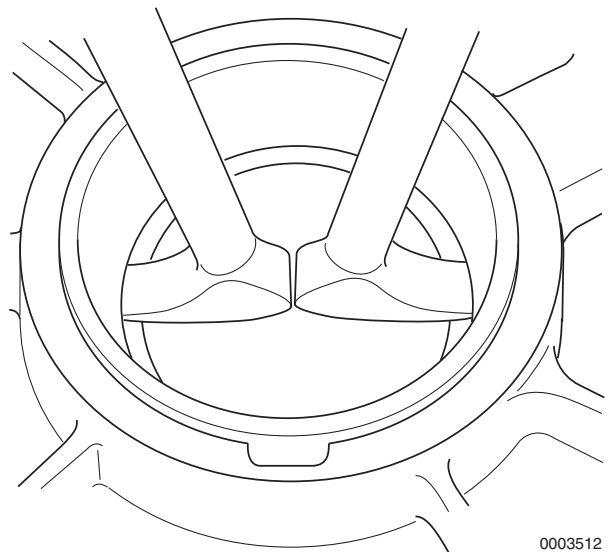
Remove the tapered roller bearing outer races by heating to approximately 120° C (250°F). The outer races will drop out as the gear cases heat up.

**WARNING! Handle the heated parts with heat-resistant gloves.**

- The case can be heated by using a torch or a heat gun.
  - Be sure to keep the shims together with the same outer races from where they were removed. Properly identify the shims and the outer races.
1. When adjustment of the shim is needed, remove the bearing races by using the rolling head pry bars or the slide hammer bearing puller.
  2. If you use a rolling head pry bar (**Figure 4-51**) for removal of case A input bearing races, use a protector (**Figure 4-50, (1)**).



**Figure 4-50**



**Figure 4-51**

3. Remove the shims from case A on the input shaft.
4. Remove the shims from case A and case B on the idle shaft.
5. Remove the shims from case A and case B on the output shaft.
6. Remove the shims from case A on the support shaft.



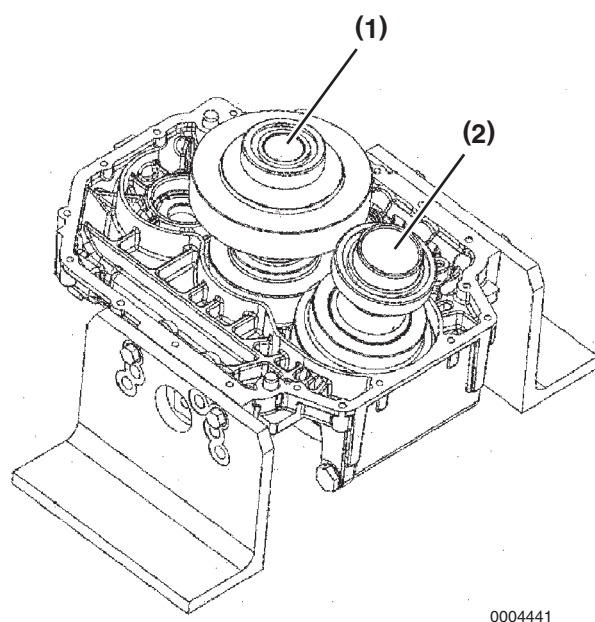
## Adjust the Gear Backlash

Note:

- The engine-side shim is for adjusting the gear backlash in case A.
- The propeller-side shim is for adjusting the bearing side clearance in case B.
- The backlash adjustment is only needed between the idle gear and the output gear.

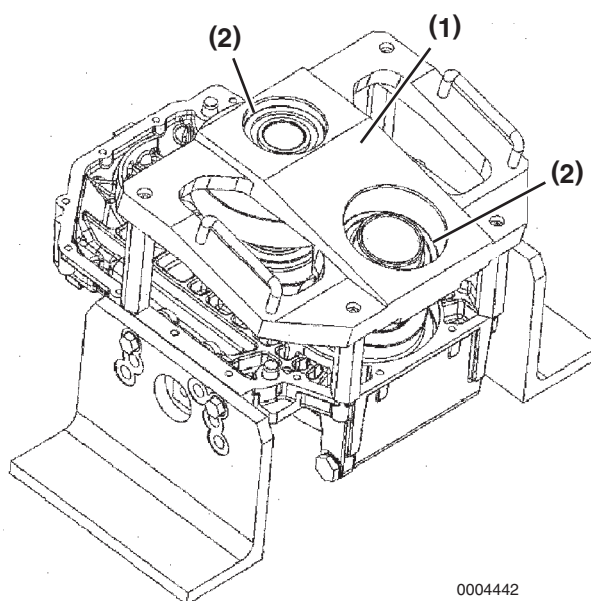
### Adjust the Gear Backlash

1. Install the idle shaft assembly in case B (**Figure 4-52, (1)**). A shim is not required under the tapered bearing cup in case B.



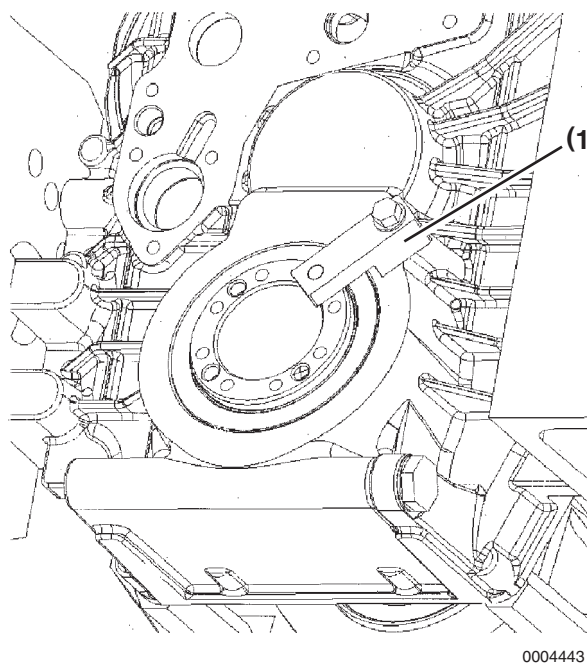
**Figure 4-52**

2. Install the output shaft assembly in case B (**Figure 4-52, (2)**). A shim is not required under the tapered bearing cup in case B.
3. Install the special tool (**Figure 4-53, (1)**). Install the outer race of each bearing onto each shaft (**Figure 4-53, (2)**).



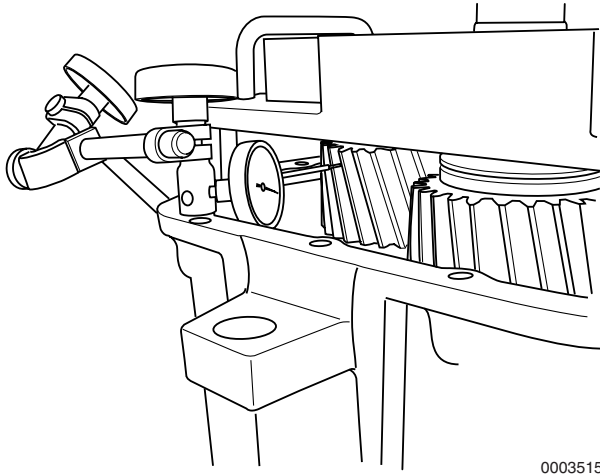
**Figure 4-53**

4. Install the shaft locking tool to the output shaft (**Figure 4-54, (1)**).



**Figure 4-54**

5. Set a dial gauge on case B with the tip of the dial indicator gauge touching the idle gear. Carefully rotate the shaft and measure the backlash between the output gear and the idle gear. Standard backlash is 0.08 to 0.16 mm (0.003 to 0.006 in.) (**Figure 4-55**).



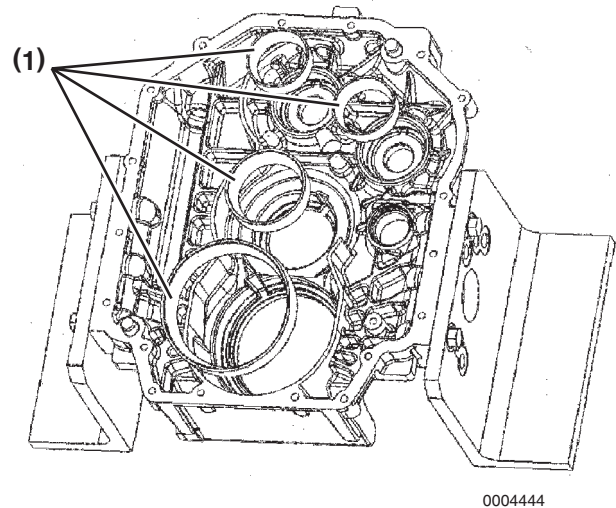
**Figure 4-55**

**Note:**

- If the backlash is 0.08 to 0.16 mm (0.003 to 0.006 in.), go to step 5.
- If the backlash is less than 0.08 mm (0.003 in.), decrease the shim thickness of the idler shaft shims. Decreasing the shim thickness by 0.1 mm (0.004 in.), increases the backlash by 0.035 mm (0.0014 in.).
- If the backlash is greater than 0.16 mm (0.006 in.), increase the shim thickness of the output shaft shims. Increasing the shim thickness by 0.1 mm (0.004 in.) decreases the backlash by 0.035 mm (0.0014 in.).

## Assemble the Tapered Roller Bearing Outer Races into Case B

1. Heat case B to approximately 120°C (250°F), and cool the outer races with dry ice or liquid nitrogen. **WARNING! Handle the heated or super-cooled parts with heat-resistant gloves.**
2. Install the outer races (**Figure 4-56, (1)**) into case B.
3. When case B has cooled down to ambient temperature, carefully seat the outer races with a copper / brass punch.



**Figure 4-56**

## Measure the Bearing Clearance / Adjusting the Bearing Preload

The required preload / play of the taper roller bearings on the individual shafts is obtained by using shims of different thickness under the outer races of the tapered roller bearings.

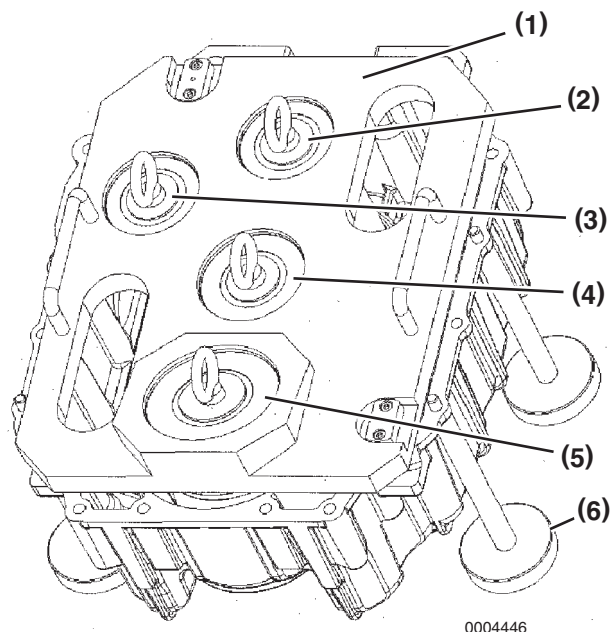
Shims which have been removed during disassembly may be reused.

### Adjust the Bearing Preload / Play

Input	Support	Idle	Output
0.05 mm Preload 0.05 mm Play	0.05 mm Preload 0.05 mm Play	0.05 mm Preload 0.05 mm Play	0 to 0.1 mm Preload

### Adjust the Bearing Clearance

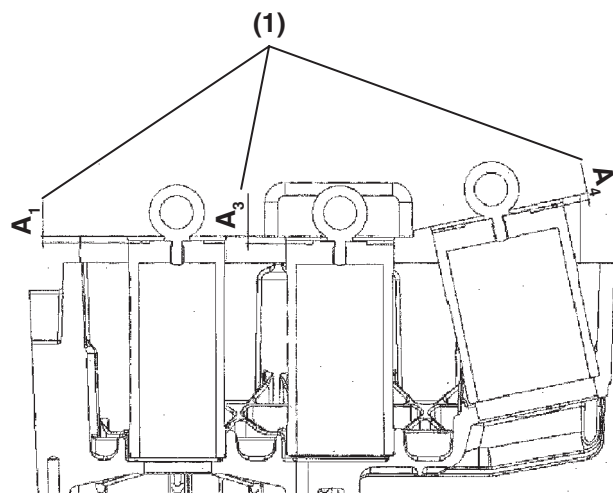
1. Install the special tools (**Figure 4-57, (1 - 6)**) on case A.



**Figure 4-57**

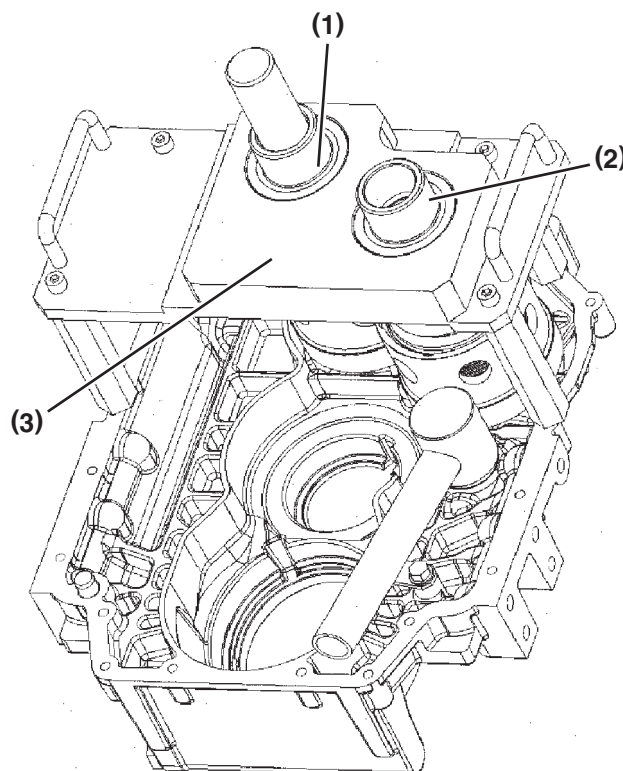
2. Use a dial gauge to measure the depth A of each individual master (**Figure 4-58, (1)**).

Note: Support shaft ( $A_2$ ) is not shown.



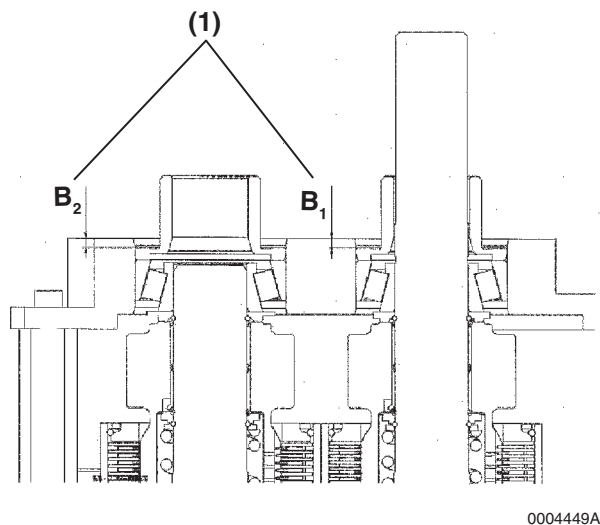
**Figure 4-58**

3. Install the special tools (**Figure 4-59, (1 - 3)**) on case B.



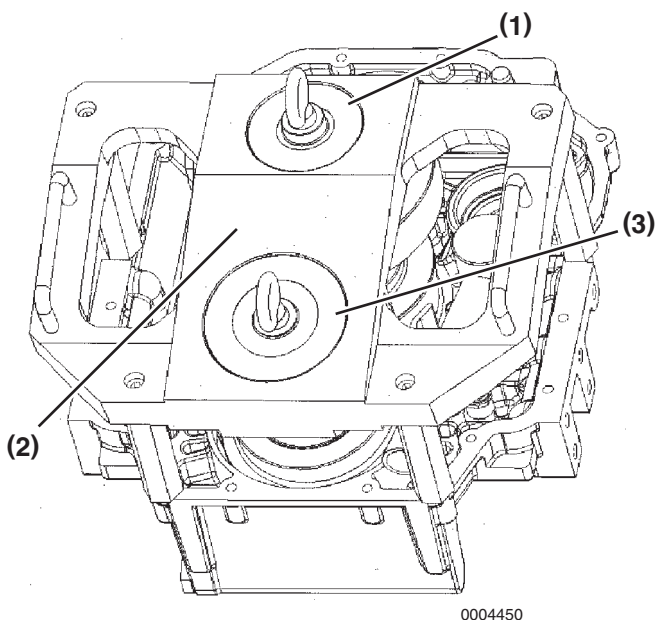
**Figure 4-59**

4. Use a dial gauge to measure the depth B of each individual master on the input and the support shafts (**Figure 4-60, (1)**).



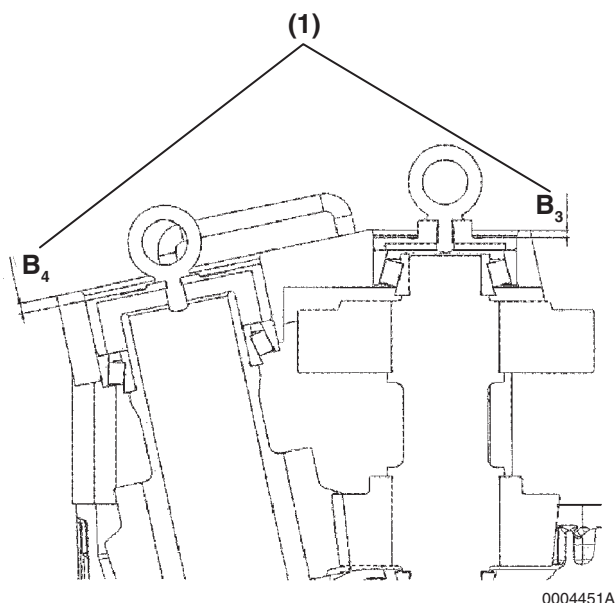
**Figure 4-60**

5. Install the special tool (**Figure 4-61, (1 - 3)**) on case B.



**Figure 4-61**

6. Use a dial gauge to measure the depth B of each individual master on the idle and the output shaft (**Figure 4-62, (1)**).



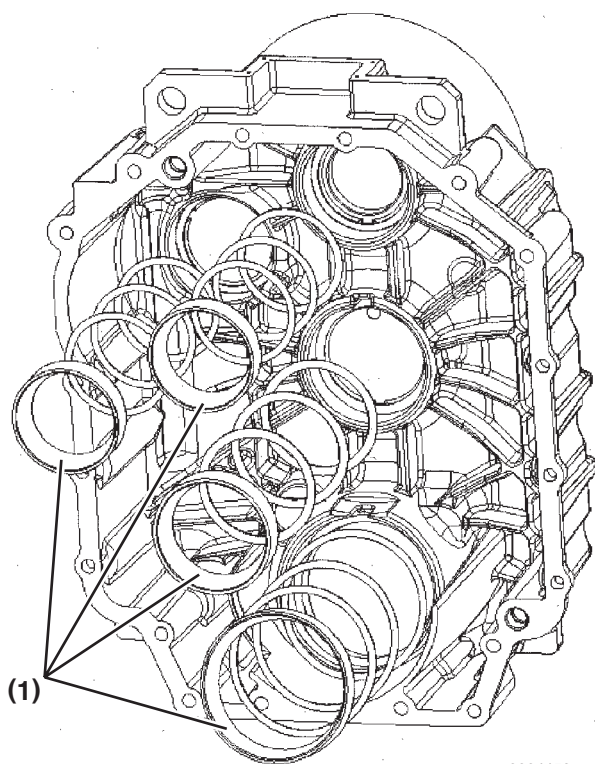
**Figure 4-62**

7. Calculate the required shim thickness (T) using the following formula:

Input Shaft	$T = A_1 + B_1 \pm 0.05 \text{ mm}$
Support Shaft	$T = A_2 + B_2 \pm 0.05 \text{ mm}$
Idle Shaft	$T = A_3 + B_3 \pm 0.05 \text{ mm}$
Output Shaft	$T = A_4 + B_4 + (0 \text{ to } 0.10 \text{ mm})$

## Assemble the Tapered Roller Bearings Outer Races into Case A

1. Use the required shim thickness determined in *Bearing Preload / Play Adjustment* and *Bearing Clearance Adjustment*.
2. Heat case A (engine side case) to approximately 120°C (250°F) and cool the outer races with dry ice or liquid nitrogen. **WARNING! Handle the heated or super-cooled parts with heat-resistant gloves.**
3. Install the shims and the outer races **(Figure 4-63, (1))** into case A.
4. When the case has cooled down to ambient temperature, carefully finish installing the outer races with a copper / brass punch.



**Figure 4-63**

## TRIAL RUN

1. Perform a trial run after filling the marine gear with oil.
2. Move the shift lever to the NEUTRAL position.
3. Start the engine. Let the engine idle with the shift lever in the NEUTRAL position for several minutes. This will ensure the oil is distributed to all the pipelines and the oil cooler.
4. Stop the engine. WAIT AT LEAST 10 MINUTES for the oil to drain back into the sump. **NOTICE:** *Never overfill the marine gear. After you add the marine gear oil, run the engine for several minutes and shut it down. Wait at least 10 minutes to check the marine gear oil level. This allows the oil to drain back into the sump, otherwise, you may overfill the marine gear with oil.*
5. Check the oil level. If necessary, add oil until the level reaches the upper mark on the dipstick. Check the oil level again after operating the marine gear for a short period of time. **NOTICE:** *NEVER overfill the marine gear with oil. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.*

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## Section 5

# TROUBLESHOOTING

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## TROUBLESHOOTING

In case of trouble, first check if all the items of the mounting and the operating instructions have been completed.

The following tables will assist you in troubleshooting.

No.	Problem	Possible Cause	Solution
1	Marine gear cannot be shifted	Shifting lever is loose.	Tighten the clamping bolt on the shifting lever.
		Remote control does not permit lever travel required for testing.	Remove the remote control. If the gears can be shifted by hand, repair the remote control.
		Remote control faulty.	Repair the remote control.
		No shifting pressure available.	Refer to No.7.
2	Delayed shift time	Shift linkage misadjusted; not allowing full engagement.	Remove the remote control. If the gears can be shifted by hand, repair the remote control. If the marine gear cannot be shifted correctly by hand, replace the control block.
3	Clutch is slipping, i.e. propeller speed too low for engine speed	Incorrect oil used.	Drain the oil, refill with the specified oil, flush the marine gear while the engine runs in NEUTRAL position, drain the oil and refill marine gear.
		Oil contains water.	Refer to No. 9.
		Shifting pressure too low.	Refer to No. 6.
		Wear on the clutch disks.	Disassemble the marine gear, replace the clutch disks. <i>See Clutch Pack Service on page 4-20.</i>
		Piston rings in the clutch are damaged.	Disassemble the marine gear, replace the clutch. <i>See Clutch Pack Service on page 4-20.</i>
4	Marine gear locked in gear	Seal ring on the input shaft or support shaft in the case plate is faulty.	Remove the case plate, replace the seal ring. If the case plate is worn, replace.
		Warped disks due to overheating of the slipping clutch.	Refer to No.3.
		Plain bearings on the input or support shaft have failed.	Disassemble the marine gear, repair if possible or replace the marine gear.



No.	Problem	Possible Cause	Solution
5	Output shaft turns in NEUTRAL position	Rotary valve in casing is worn.	Replace the rotary valve.
		Faulty plain bearing on the input or support shaft.	Disassemble the marine gear and input or support shaft, replace the bearing and other damaged parts.
		Warped disks due to overheating of the slipping clutch.	Refer to No. 3.
6	Shifting pressure too low	Oil strainer clogged.	Wash the strainer or replace.
		Oil level in the marine gear too low.	Fill with oil. In case of oil loss, check the marine gear, cooler and pipelines for leakage and repair. Refer to No. 10 through No. 13.
		Oil pump is worn out.	Replace the oil pump.
		Spring in shifting pressure relief valve is broken.	Replace the spring.
		Seal rings on the input shaft or the support shaft are faulty.	Remove the case plate, replace the seal ring. If the case plate is worn, replace.
		Throttle valve for shifting pressure is broken.	Replace the throttle valve.
		Piston rings in the clutch are faulty.	Disassemble the marine gear. Replace the clutch. <i>See Clutch Pack Service on page 4-20.</i>
		Choke port at the modulator valve obstructed.	Wash the modulator valve.
7	No shifting pressure available	Direction of the engine rotation does not agree with arrow on the marine gear.	Replace with engine that has correct rotation.
		No oil in the marine gear.	Refill with oil.
		Strainer is dirty.	Clean or replace the oil strainer.
		Oil level in the marine gear is too low.	Fill with oil. In case of oil loss, check the marine gear, cooler and pipelines for leakage and repair. Refer to No. 10 through No. 13.
		Oil pump is worn out.	Replace the oil pump.
		Spring in the shifting pressure relief valve is broken.	Replace the spring.
		Throttle valve for shifting pressure is broken.	Replace the throttle valve.
8	Excessive oil temperature	Excessive oil in the marine gear.	Remove excess oil with the commercial suction pump.
		Oil cooler is dirty on the water side.	Clean the oil cooler on the water side.
		Worn oil pump.	Replace the oil pump.
		Seal rings on the input shaft or the support shaft are faulty.	Remove the case plate, replace the seal ring. If case plate is worn, replace.
		Clutch is slipping.	Refer to No.3.
		Clutch does not open completely due to the worn disk support.	Separate the marine gear and the coupling. Replace the inner disk support and / or the clutch.



No.	Problem	Possible Cause	Solution
9	Water in the oil, oil looks milky	Oil cooler faulty.	Repair leakage at the cooler or replace the cooler.
		High water level in the engine compartment, water entering through the output shaft seal.	Investigate the cause for water level in the engine compartment. Repair the cause. Replace the marine gear.
10	Oil leakage at output shaft	Breather clogged.	Remove the contamination from breather.
		Shaft seal faulty.	Disassemble the marine gear. Replace the seal. If the seal location on output shaft is worn, seal lip should be mounted offset.
11	Oil leakage at breather	Excessive oil in the marine gear.	Remove the excess oil with the commercial suction pump.
12	Oil leakage at joints	Bolts are loose.	Tighten the bolts to the specified torque.
		Seals on the bolts have been damaged.	Replace the seals, tighten the used bolts to the specified torque.
		Mating faces are contaminated, no surface seal applied.	Unscrew the case halves, finish the mating surfaces with the oilstone or the finishing file, apply the surface seal. Assemble the marine gear, tighten the bolts to the specified torque.
13	Marine gear noise becomes louder	Oil level too low - pump sucks in air.	Fill with oil to the marking on the dipstick. See <i>Checking Oil Level on page 4-40</i> .
		Damage to the flexible coupling due to the misalignment between the engine and marine gear.	Replace the flexible coupling. Check the alignment between the engine and marine gear.
		Bearing damage in the marine gear, e.g. due to torsional vibrations, running without oil, overload, wrong alignment of marine gear, excessive engine output.	Disassemble the marine gear, replace the bearings if damaged and other faulty parts. Find the causes and repair.
		Gear damage, e.g. due to torsional vibrations, running without oil, overload.	Disassemble the marine gear, remove the faulty parts.
		Oil suction cover in the marine gear is loose.	Disassemble the marine gear, tighten the oil suction cover.
14	Chattering marine gear noise mainly at low engine speed	Misaligned jack shaft on the input or output.	Mount and align the jack shaft strictly according to the instructions issued by the jack shaft manufacturer.

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## Section 6

# OPTIONAL ACCESSORIES

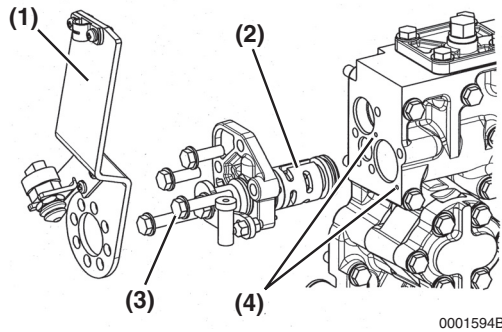
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# ELECTRIC SHIFT VALVE

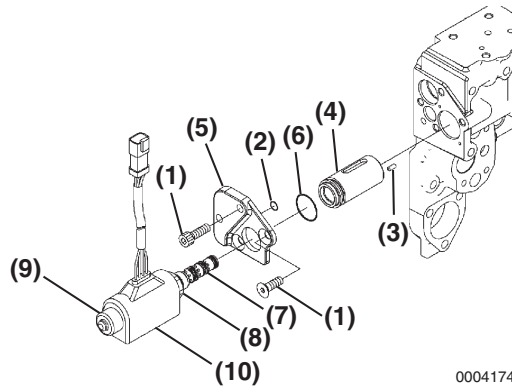
## Installation of the Electric Shift Valve

1. Remove the hex head bolts **(Figure 6-1, (3))** retaining the mechanical shift valve.
2. Remove the mechanical shift bracket **(Figure 6-1, (1))**.
3. Pull out the mechanical shift valve and the cover **(Figure 6-1, (2))**.
4. Remove the locating pins **(Figure 6-1, (4))**.



**Figure 6-1**

5. Install the O-ring **(Figure 6-2, (6))** on the sleeve **(Figure 6-2, (4))**.



**Figure 6-2**

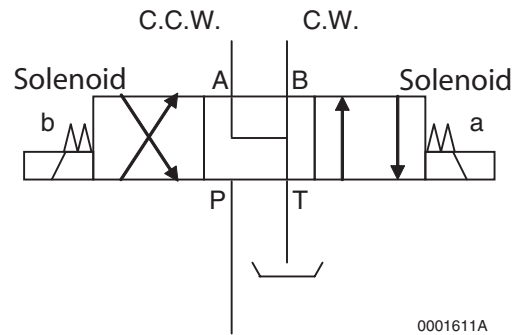
6. Insert the locating pin **(Figure 6-2, (3))** in the hole of the sleeve.
7. Insert the sleeve **(Figure 6-2, (4))** in the case plate.
8. Insert the O-ring **(Figure 6-2, (2))** in the cover **(Figure 6-2, (5))**.

9. Install the cover on the case plate with the four hex head bolts **(Figure 6-2, (1))**.
10. Install the electric shift valve **(Figure 6-2, (7))**. Torque the bolt **(Figure 6-2, (8))** to 16.7 N·m (12.3 ft-lb).
11. If the solenoid was removed from the shift valve **(Figure 6-2, (7))**, install the solenoid **(Figure 6-2, (10))** with the arrow on the solenoid facing the case plate.
12. Thread the nut **(Figure 6-2, (9))** on the electric valve. Torque the nut to 3.2 N·m (28 in-lb).

## Electric Shift Valve Wiring

After installation of the electric shift valve, wire the electric shift valve as follows:

### Hydraulic Symbol



**Figure 6-3**

Wire the selecting switch circuit and the neutral safety circuit using the following example as a guide.

Note: Use the same numbers between the electric shift valve connector and each circuit.

No.	Color	Note
D10	Red	Solenoid a
D11	Black	Solenoid a
D12	Blue	Solenoid b
D13	White	Solenoid b

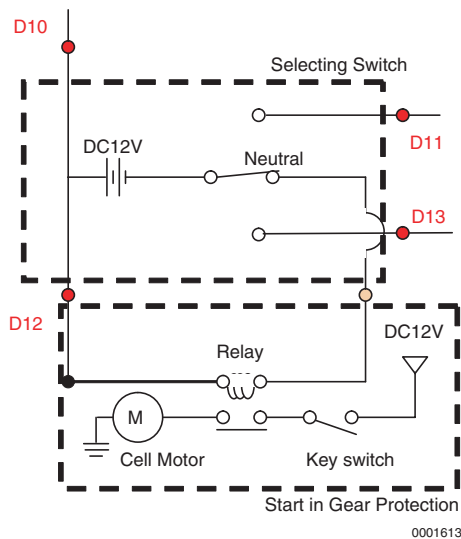


Figure 6-4

## Emergency Operation of the Electric Valve

If the electric valve stops operating, do the following:

### Current Production Models

1. With the engine not running, remove the cap (Figure 6-5, (1)), and the emergency nut (Figure 6-5, (2)). **CAUTION! If you have more than one engine, you cannot shift the marine gear into the "B" position after you install the emergency nut.**

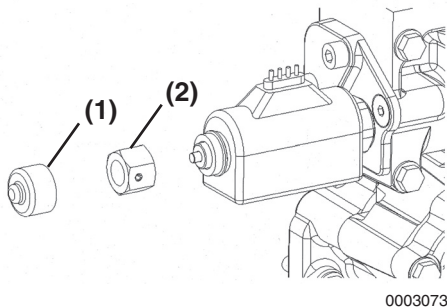


Figure 6-5

2. Reverse the emergency nut (Figure 6-6, (1)) and thread it onto the electric valve. **WARNING! When you reverse the emergency nut, the boat will move forward as soon as you start the engine! There is no neutral safety protection in this mode. Make sure the area is clear before you start the engine.**

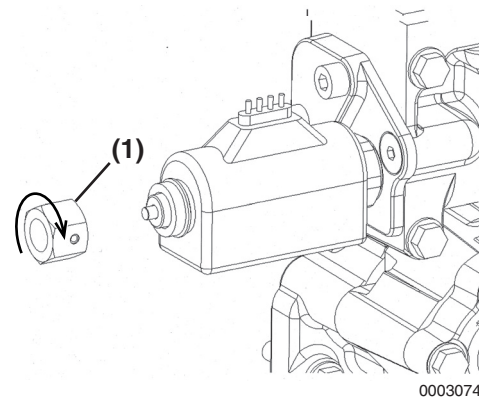
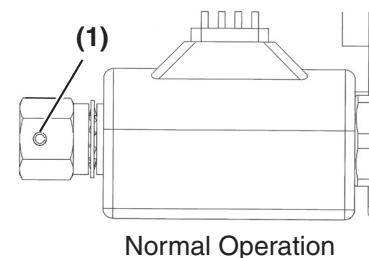


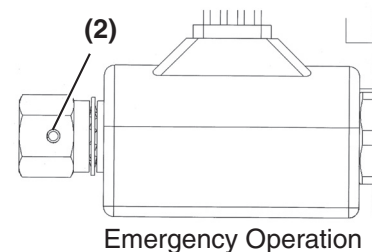
Figure 6-6

Note: Notice the orientation of the spring pin in the emergency nut.

- Normal operation (Figure 6-7, (1))
- Emergency operation (Figure 6-7, (2))



Normal Operation

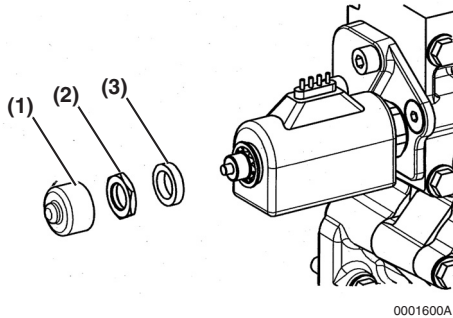


Emergency Operation

Figure 6-7

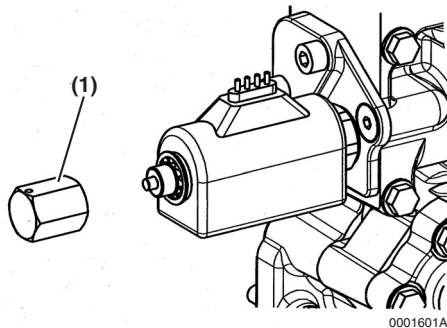
### Past Production Models

1. With the engine not running, remove the cap (**Figure 6-8, (1)**), the nut (**Figure 6-8, (2)**) and the collar (**Figure 6-8, (3)**). **CAUTION! If you have more than one engine, you cannot shift the marine gear into the "B" position after you install the emergency nut.**



**Figure 6-8**

2. Thread the emergency nut (**Figure 6-9, (1)**) onto the electric valve. **WARNING! When you reverse the emergency nut, the boat will move forward as soon as you start the engine! There is no neutral safety protection in this mode. Make sure the area is clear before you start the engine.**



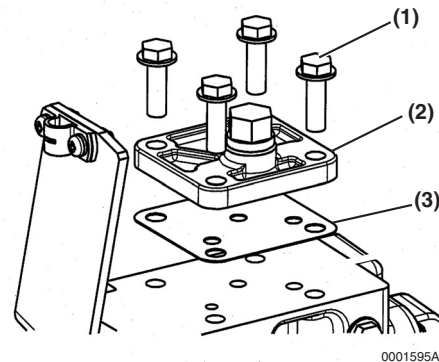
**Figure 6-9**

## MECHANICAL TROLLING VALVE

With this trolling valve, the marine gear shifting pressure is lowered to about 0.1 - 0.2 MPa (14 - 29 psi). The clutch will slip and the propeller will rotate at a low speed allowing the boat to move very slowly. This trolling valve does not give feedback of the fluctuations in the propeller speed.

### Installation of the Mechanical Trolling Valve

1. Remove the four M8x25 hex head bolts (**Figure 6-10, (1)**).
2. Remove the upper cover (**Figure 6-10, (2)**) and the gasket (**Figure 6-10, (3)**).



**Figure 6-10**

3. Position the new gasket (**Figure 6-11, (3)**).
4. Install the trolling valve with the four M8x60 hex head bolts and the lock washers (**Figure 6-11, (2)**). Torque the bolts (**Figure 6-11, (1)**) to 22.6 N·m (204 - 252 in-lb).

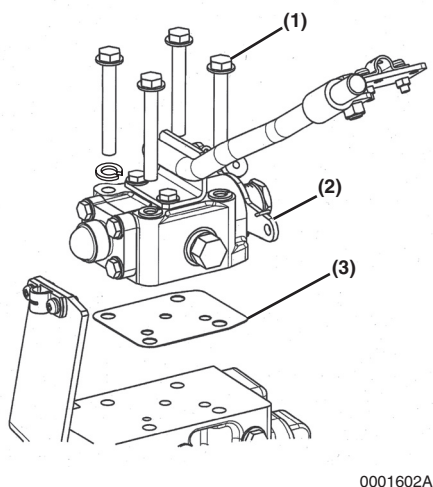


Figure 6-11

### Oil Pressure Adjustment

When the rubber cap (**Figure 6-13, (1)**) is removed, the locknut (**Figure 6-13, (2)**) is loosened, and the adjustment screw (**Figure 6-13, (3)**) is rotated clockwise (tightened), the angle of the lever (**Figure 6-14, (1)**) lowers the shifting pressure and reduces the speed of the boat. **NOTICE:** Use the trolling valve once daily. The orifice (**Figure 6-13, (4)**) can clog when the trolling valve is not used for extended periods of time, resulting in the unexpected engagement of the valve.

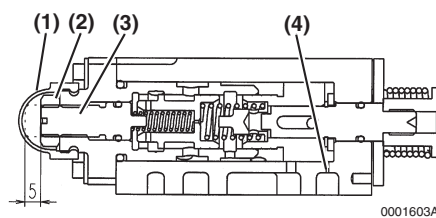


Figure 6-13

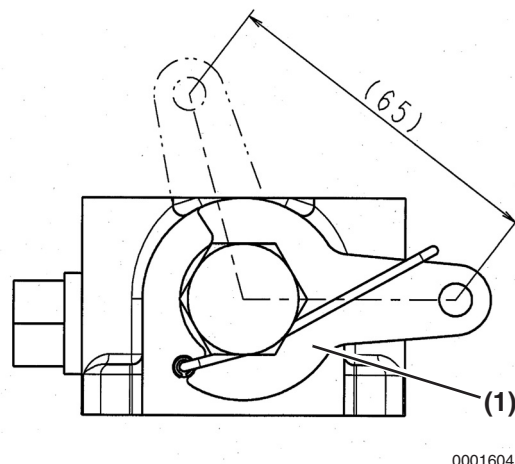


Figure 6-14

Note: When the trolling valve is not being used, secure it in place so that it does not move from the vibration of the boat.

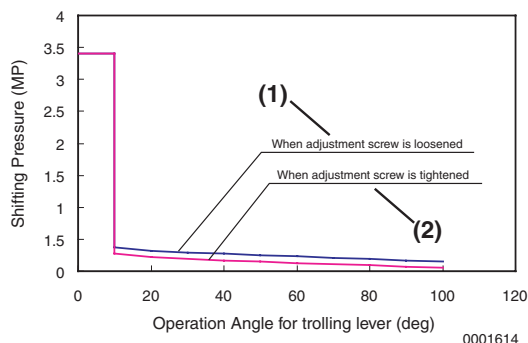


Figure 6-12

## ELECTRIC TROLLING VALVE

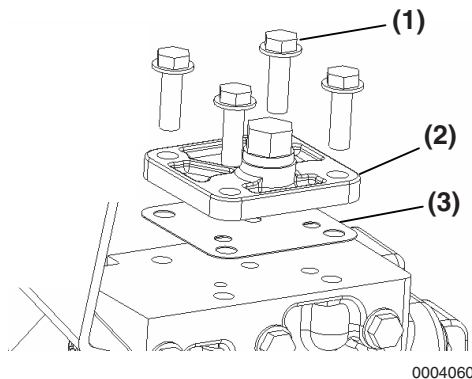
With an electric trolling valve, the marine gear shifting pressure is lowered to about 0.1 - 0.2 MPa (14 - 29 psi). The clutch will slip and the propeller will rotate at a low speed allowing the boat to move very slowly.

The E-type trolling valve does not give feedback on the fluctuations of the propeller speed.

The C-type trolling valve does give feedback on the fluctuations of the propeller speed.

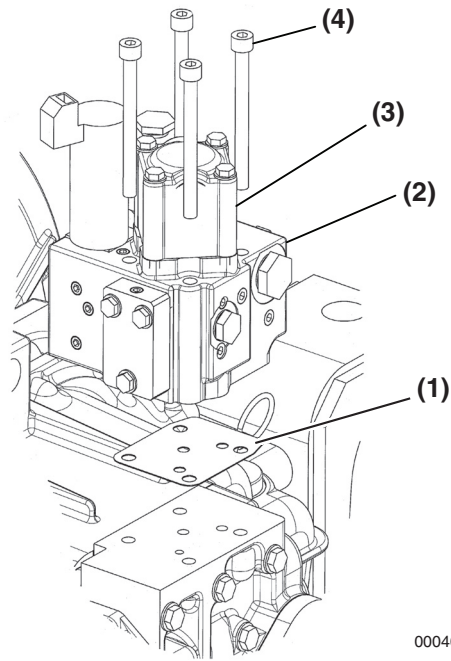
### Installation

1. Remove the four hex head bolts (Figure 6-15, (1)).
2. Remove the upper cover (Figure 6-15, (2)) and the gasket (Figure 6-15, (3)).



**Figure 6-15**

3. Install the new gasket (Figure 6-16, (1)).



**Figure 6-16**

4. Install the electric trolling valve (Figure 6-16, (2)). Torque the hexagon socket head bolts (Figure 6-16, (3)) to 20.6 N·m (182 in-lb).

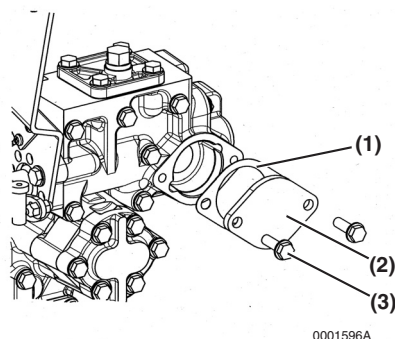


## PTO SPLINE SLEEVE AND FLANGE

### Specifications

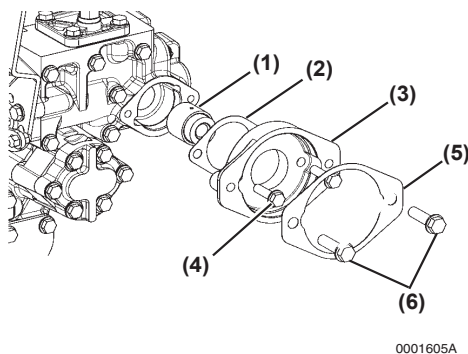
Item	Specification
Spline Size	SAE Z=9, DP16/32, 30° Class I
Flange Size	SAE Type A
Permissible Input Torque	120 N·m (88.5 lb-ft)

### Installation of the PTO Spline Sleeve and the Flange



**Figure 6-17**

1. Remove the PTO cover bolts (**Figure 6-17, (3)**).
2. Remove the PTO cover (**Figure 6-17, (2)**) and the gasket (**Figure 6-17, (1)**). Discard the gasket.



**Figure 6-18**

3. Insert the spline sleeve (**Figure 6-18, (1)**) onto the input shaft.

4. Use a new gasket (**Figure 6-18, (2)**), position the PTO flange with the M8x30 hex head bolts (**Figure 6-18, (3)**). Torque the hex head bolts (**Figure 6-18, (4)**) to 22.6 N·m (204-252 in-lb). See *Standard Torque Values* on page 4-13.
5. Install the PTO device with the M10x35 hex head bolts (**Figure 6-18, (6)**).

#### Note:

- The PTO device is purchased separately by the customer.
- NEVER operate the marine gear without a PTO cover plate or a device installed. Operating the marine gear without a PTO cover plate or a device installed will cause the marine gear oil to leak out.

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